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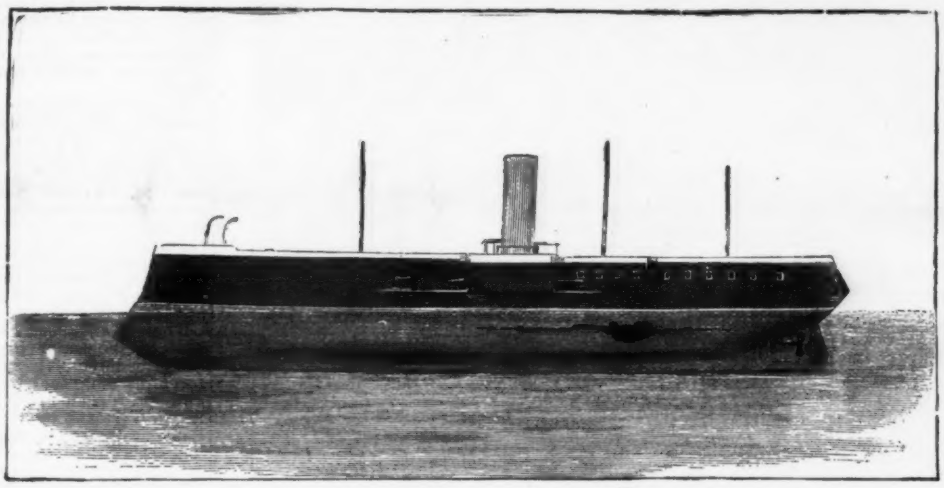
THE CIVIL WAR IN CHILE.

SOUTH AMERICA has taught us more than the other quarters of the world combined concerning the conditions and possibilities of modern naval warfare. The bloody actions in Paraguay during the struggle of the Dictator Lopez with his two powerful neighbors showed us the value of small armored vessels for river work; the long continued war between Chile and Peru, and the exploits of the *Huascar*, the *Blanco Encalada*, the *Almirante Cochrane*, and other craft of comparatively recent types, enabled us to form some idea of the growing importance of speed and of machine-gun fire, and of the great part which chance must play in all future combats afloat; and now the Chilean civil war is teaching us a rapid succession of lessons, which, although they have not hitherto upset many preconceived theories, are intensely interesting, and, if read aright, should be very useful.



THE INJURY DONE TO THE BLANCO ENCALADA BY THE TORPEDO FIRED BY THE ALMIRANTE LYNCH.

The hole is 16 ft. by 4 ft., with a continued rent fore and aft of about 20 ft. each way.

At the outset of the conflict between President Balmaceda and the Congressionalists, nearly the whole of the Chilean navy joined the latter, and the only vessels of war of any importance that remained to the President were the sister torpedo gun vessels *Almirante Lynch* and *Almirante Condell*, which had just previously been built in England by Messrs. Laird, of Birkenhead, and which were not actually delivered until after the commencement of hostilities. These craft bear a very close resemblance to our own torpedo gun vessels of the *Sharpshooter* type. Each measures 240 ft. long by 27 ft. 6 in. broad, with a displacement of 750 tons at a draught of 9 ft. 6 in. There are twin screws driven by engines of 4,500 combined horse power, giving an extreme speed under forced draught of 21 knots per hour. The armament of each is two 14-pounder quick-firing guns, two 3-pounder quick-firing guns, two machine guns, and four torpedo-launching tubes; and the proper complement was about ninety officers and men. The Congressionalists, on the other hand, had what was, comparatively speaking, a powerful fleet, manned by the best officers and blue jackets of a country which possesses a naval history to be proud of, and which has produced some naval heroes, such as Arturo Prat and Admiral Latorre, who may almost be counted in the first rank.

Both sides also disposed of a few torpedo boats and transports, and at the outbreak of hostilities set to work to fit as many merchant steamers as possible for war purposes. The Balmacedists were fortunate in being able to lay hold, for this object, of the fast steamer *Imperial*, a vessel of 2,700 tons register and 3,000 indicated horse power, belonging to the Compania Sud Americana de Vapores, of Valparaiso. They used her for a month or two as a blockade runner, and five times she successfully evaded the Congressionalist fleet; but they seem to have soon felt that the breaking of blockades, no matter how often effected, could never end the war; and in April they determined to utilize her as a regular cruiser. They therefore fitted out at Valparaiso a little force consisting of the *Imperial, Almirante Lynch, Almirante Condell, Sargente Aldea* (a 70-ton torpedo boat capable of an extreme speed of about twenty-one knots), and *Guacolda* (a 90 ton torpedo boat of 22 knots speed), and on April 13 dispatched it to the northward with sealed orders. At that time several Congressionalist vessels were lying in the neighborhood of Caldera and Chanaral, in an open bay. Caldera itself had a few days previously been occupied by the Congressionalists, and such batteries as it possesses had been manned by their troops. On the morning of April 23, at four o'clock, the weather being clear and the lighthouse lamp still burning brightly, the Balmacedist squadron arrived off Caldera, which is a few miles to the southward of Chanaral. Under the batteries of Caldera lay the *Blanco Encalada*, moored to a buoy about a mile from the shore, and accompanied only by the transport *Bio-Bio*. Her fires were banked, and, by perfectly inexcusable neglect, she neither had picket boats cruising in the offing on the look-out nor torpedo nets rigged. In fact, none of the ordinary precautions had been taken,

The Almirante Condell. The Blanco Encalada. The Almirante Lynch.

THE SINKING OF THE REBEL SHIP BLANCO ENCALADA BY THE GOVERNMENT TORPEDO CATCHERS ALMIRANTE LYNCH AND ALMIRANTE CONDELL, IN CALDERA HARBOR.

and the ironclad's guns were not even cleared for action. Commander Fuentes, of the *Almirante Lynch*, who was senior officer, was informed by Commander Moraga, of the *Almirante Condell*, which was leading, of the presence of the battleship, and appears to have signaled to his other consorts to remain outside, and then to have ordered the *Almirante Condell* to proceed, and to have followed her. According to the official Balmacedist report, Don Pedro Salva, First Lieutenant of the *Almirante Lynch*, called all hands on deck, and offered to put ashore any man who might feel indisposed to fight, but no one took advantage of the opportunity. So bad was the watch on board the *Blanco Encalada* that she did not open fire until her enemies, who had slowed down as they drew near, were within two hundred yards of her. She then began to ply them with canister, and one of her first discharges killed three men on the deck of the *Almirante Condell*, which, in the meantime, had been seriously discommoded by the giving out of a large number of her boiler tubes. The confusion thus occasioned on board of her is, no doubt, responsible for the extraordinary fact that, although at this period she fired two Whiteheads, when at a distance of only a hundred yards from her prey, both weapons missed their mark. One, indeed, passed as much as fifty feet astern of the ironclad. The *Condell* had slowed down broad on the starboard beam of the *Blanco Encalada*, and the *Lynch*, after seeing the *Condell's* torpedoes discharged, appears to have passed on inside of her, within fifty feet of the *Blanco*, and to have fired two more torpedoes as she went, but they also missed, and no sooner had they been let go than a hand grenade, thrown from the *Blanco*, exploded on the *Lynch's* deck and killed six men. The *Lynch* now seems to have turned to port, and to have again passed the *Blanco*, this time so closely as to almost touch her. As she went, she fired her third torpedo, which struck the *Blanco* just abaft the citadel on the starboard side, and rent a great hole in her sixteen feet by four. The ironclad heeled over and at once began to sink. For a brief period there was a terrible scene; but within ten minutes the vessel disappeared, carrying with her 150 of her officers and men, and leaving only her topmasts showing above water. The *Condell* was but little damaged; the *Lynch* had been struck twelve times, had lost several officers and men, and was making water rapidly. Our sketch is from the *London Graphic*. It was made by Chas. Raxworthy, R.N., who was an eye-witness of the scene.

The Congressionalist navy included the following ships, of which the first three were ironclads:

Ship.	Date.	Tons.	I.H.P.	Speed in Knots.	Guns.	Men.
Almirante Cochrane ...	1874	3,370	2,950	12·7	6	242
Blanco Encalada.......	1875	3,470	2,920	12·0	6	238
Huascar..............	1865	2,032	1,050	11·3	4	134
Esmeralda	1883	2,810	6,500	18·3	8	
Amazonas............	1874	2,000	2,400	13·2	1	145
Chacabuco............	1866	1,490	1,200	10·0	7	129
O'Higgins.............	1866	1,490	1,200	10·0	7	129
Abtao	1864	1,370	1,100	9·0	5	179
Angamos............	1876	1,200	1,485	18·5	1	110
Magellanes.........	1874	950	1,240	11·0	2	105
Pilcomayo...........	1874	800	1,080	10·0	6	128

THE FIRING OF THE 110 TON GUN.

WE will assume that this great gun is on the point of being fired with a full charge. The 110-ton gun, indeed all large guns, are fired with slow-burning cocoa powder—"cocoa" because of its brown color. As you may observe in the powder case in the gallery, it is shaped in hexagonal prisms, this being the most convenient form for close packing. Each prism is pierced with a hole in the center, so as to give ready access to the flame and insure an equable ignition. Ten thousand of these prisms are needed to make up a full charge for this monster gun. The powder, along with the shell, comes up from the magazine below in a hoist (indicated at the rear of the model), and, having been placed on a spout tray, is rammed into the gun by a hydraulic rammer (also indicated at the rear of the model), the shell, of course, having been first driven forward into its place by the same instrument.

In nearly all naval guns the powder charge is made up into four cartridges, the object being to get each cartridge down to a weight that a man may lift. But on account of its extraordinary weight—960 lb.—the charge for the 110-ton gun is divided into eight cartridges. Specimens of these cartridges, to the extent of the full charge, stand as a pyramid close to the hoist. The material of the envelope, by the way, is silk cloth. At the back of each envelope, next to the primer, there stand a few prisms of black powder, because it more readily ignites than the cocoa powder. Each of these eight cartridges weighs 120 lb. To load, it is necessary to bring the gun in at extreme elevation, and then the following operations are gone through:

1. Unlock and unscrew the breech block.
2. Withdraw breech block.
3. Traverse breech block to one side.
4. Place the loading tray in the gun.
5. Wash out the gun.
6. Ram home the projectile.
7. Ram home first half charge.
8. Ram home second half charge.
9. Withdraw loading tray.
10. Traverse breech screw.
11. Insert breech screw.
12. Screw up and lock breech screw.

All these operations are performed by hydraulic machinery, and are all so provided with simple arrangements to prevent mistakes, aver Messrs. Armstrong, Mitchell & Co., that accidents practically never happen. The gun having been sighted by the captain of the turret from his conning tower, is also fired by him by electricity. The gun can be loaded and fired within two and a half minutes.

THE SHOT AND ITS TERRIBLE HAVOC—A GRAPHIC PICTURE.

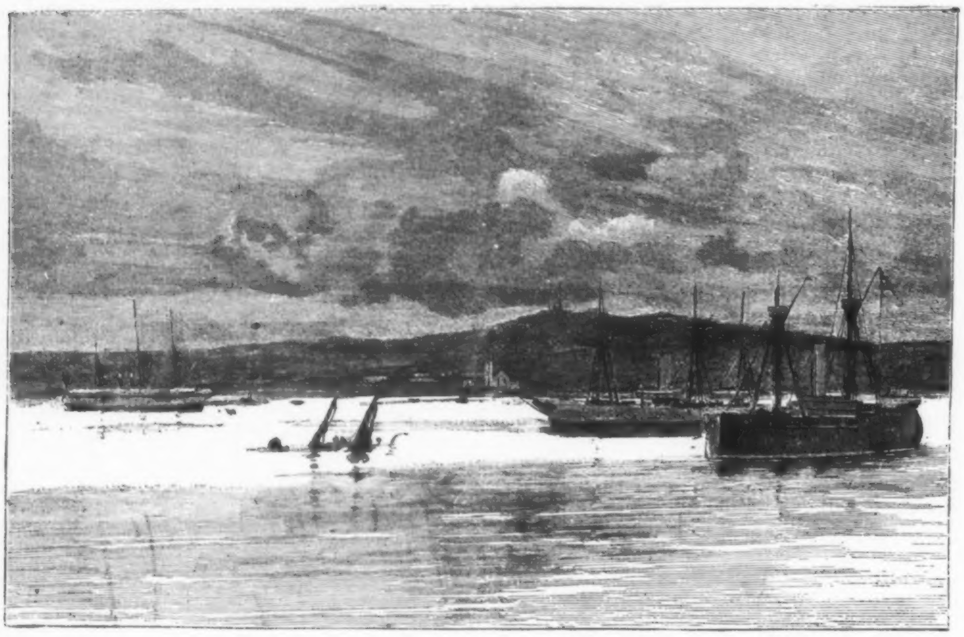
The projectile fired from the gun when attacking ships or forts weighs 1,800 lb., and it goes out with a velocity of 2,105 ft. per second, and has a destructive energy equal to 55,305 foot tons. If the gun were to be used against a body of men or a flotilla of boats, shrapnel shell would be used; that is the long, drum-like cylinder of steel standing close to the carriage would be shot from the gun, and its contents—2,300 4 oz. bullets—would scatter death among the foe. The bullets are put in in layers, though not with mathematical exactness, they are merely shaken together. Melted resin is poured in among them, in order to fill up the interstices; else, when the heavy shock of the explosion came, they would be all flattened against each other.

Directly the shrapnel case bursts the bullets go flying on, while the spin of the shell, communicated by the rifling of the gun, spreads them out by centrifugal force over a large area. But the gun will most likely be used for attacking armored ships and forts. In this case the steel shell, with a strong, sharp point, will be used. These shells are first forged, then bored, and finally tempered. While they should be tough in the body, they must be hard at the striking point. The hardness of the point increases the penetrative power of the shell, while the toughness of the body prevents its swelling as it is entering the plate and so increasing the difficulties of penetration. A good shell carries itself into the interior of the ship before it explodes. The shell is constructed to carry such an amount of powder as will cause it to explode and add its pieces to the destructive splinters from the broken plate. The shell used in this gun, as stated, weighs 1,800 lb. The terrible havoc which such a shell will play when fired with a full charge from this gun was most vividly illustrated by the course of a shell from the 110-ton gun of the Sanspareil at a trial Shoeburyness in March last. The shell tore its way at the rate of 2,079 ft. per second through 20 in. of compound armor specially manufactured, 8 in. of iron fastened in a heavy wrought iron frame, 20 ft. of oak balks, 5 ft. of granite blocks, 11 ft. of concrete, and 6 ft. of brick; altogether, 44 ft. 4 in. of a wall unique in history, surely, for combination of width and variety and strength of material. For firing a full charge with armor-piercing shot from the 110-ton gun, the country pays for the powder, $400; for the shell and fuses, $600; total, $1,000; not to mention a much more serious item if the gun were continually being fired with a full charge, the damage from the erosion caused by the powder gases, which causes it to lose its accuracy, and necessitates its being relined, at great expense and at the cost of long delay. But it is right to say the gun is seldom fired with its full charge.

Provision, in the shape of sights and range tables, is provided, with all our heaviest guns, for three charges, namely, the half charge, three-quarters charge, and full charge. It is laid down in the regulations that for peace practice the first is to be used, besides an occasional round of the second to test the proper working of the mounting; the full charge being reserved for special cases during war, when the position of the ship requires extraordinary exertions to cripple her enemy. It is generally considered, says Captain Noble, in "Modern Naval Artillery," that the life of the 67-ton guns may be taken at 120 rounds, and the 110-ton gun at 75 rounds, both with full charges.

The era of these very heavy guns practically dates back twelve years. Since then thirty 100 and nine 110-ton guns have been manufactured. Most of the 100-ton guns went to Italy, two of them are at Gibraltar and Malta respectively. Of the 110-ton guns, two are in the Victoria, two in the Benbow, and two in the Sanspareil; and there is one spare one in each ship. The use of these huge guns can be defended; as Captain Noble asks in the work about to be issued by the Elswick firm: "What would have been said by the country, and above all by the very newspaper correspondents who now fall so foul of them, had one of our ships armed with, say, 67-ton guns been destroyed in war by an enemy carrying 100-ton guns?" But, as Captain Noble acknowledges, their day is over. "For, tempting as the surprising results of power which are obtained by them may be, it is easy to see that these are expensively purchased, not only in the actual cost of the gun and its ammunition, but also in the size of ships required to carry them."

Guns of the 67-ton type are fitted on the Nile and Trafalgar and our later men-of-war. The 110-ton gun takes nearly two years to make, and costs, with mounting and machinery, nearly £20,000; the 67-ton gun takes eighteen months to make, and costs about £14,000. So at least the country will save time and money by this change of policy.—*Pall Mall Budget.*



THE LAST OF THE BLANCO ENCALADA IN CALDERA HARBOR.

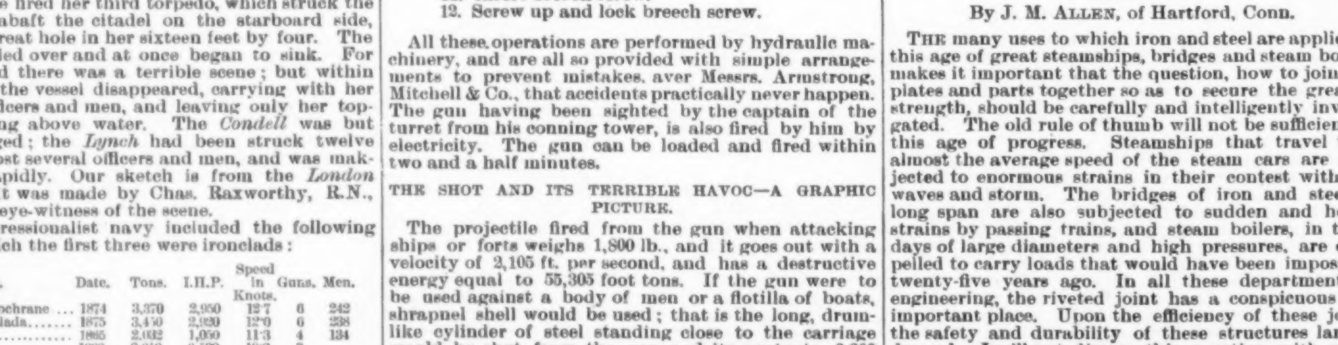
SIBLEY COLLEGE LECTURES.—1890-91.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

RIVETED JOINTS—THEIR PROPORTIONS AND STRENGTH.

By J. M. ALLEN, of Hartford, Conn.

THE many uses to which iron and steel are applied in this age of great steamships, bridges and steam boilers makes it important that the question, how to join the plates and parts together so as to secure the greatest strength, should be carefully and intelligently investigated. The old rule of thumb will not be sufficient in this age of progress. Steamships that travel with almost the average speed of the steam cars are subjected to enormous strains in their contest with the waves and storm. The bridges of iron and steel of long span are also subjected to sudden and heavy strains by passing trains, and steam boilers, in these days of large diameters and high pressures, are compelled to carry loads that would have been impossible twenty-five years ago. In all these departments of engineering, the riveted joint has a conspicuous and important place. Upon the efficiency of these joints the safety and durability of these structures largely depend. I will not discuss this question with reference to its bearing upon steamships and bridges, but will confine myself to the importance of a proper and intelligent understanding of the various forms of riveted joints as applied in the construction of steam boilers. Up to the year 1838 there had been little or no scientific investigation of this subject. In the early part of this century, boilers were used only at low pressures. Most of the engines were of the condensing type. But the rapid introduction of steam power in the industrial world, with the improvements in boilers and engines, soon called for higher pressures and stronger boilers. In 1838, Sir William Fairbairn conceived the importance of thoroughly investigating the



question of proper construction of boilers, with a view to greater safety and efficiency. He made numerous practical tests of the strength of materials, particularly of iron, and also of the strength of riveted joints, the results of which are in some cases accepted to-day. It is interesting to read his account of these experiments. He was working in a new field, and the results of his careful and painstaking work have laid us all under great obligation. I quote from him the following in regard to riveted joints: "Up to the present time nothing of consequence has been done to improve or enhance the value of this process. We possess no facts nor experiments calculated to establish principles sufficient to guide our operations in effecting constructions of this kind, on which the lives of the public as well as the property of individuals depend. In fact, such has been our ignorance of the relative strength of plates and their riveted joints, that, until the commencement of the present inquiry, the subject was considered of scarcely sufficient importance to merit attention. Even now it is by many assumed that a well riveted joint is stronger than the plate itself, and a number of persons, judging from appearances alone, concur in that opinion. Now, this is a great mistake; and, although the double thickness of the joint indicates increased strength, it is nevertheless much weaker than the solid plate, a circumstance of some importance, as we hope to show in the following experiments."

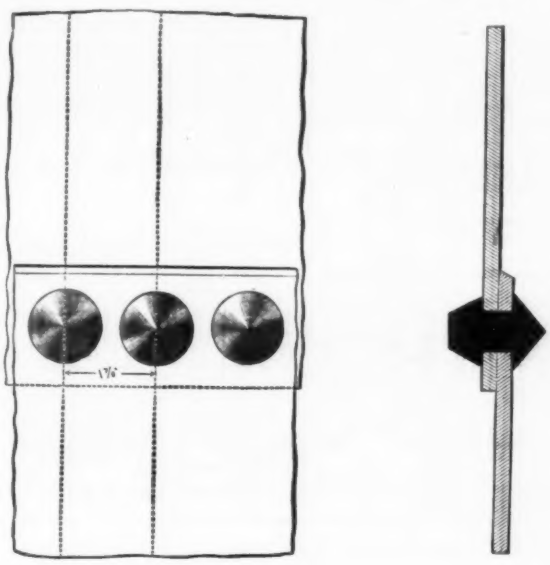


FIG. 1.

Without going through the details of his experiments, I will simply give his conclusions. He says, from the foregoing: "We may fairly assume the following relative strengths as the value of plates with their riveted joints:

"Taking the strength of the plate at 100, the strength of the double-riveted joint would be 70, and the strength of the single-riveted joint would be 56."

SINGLE-RIVETED JOINTS.

In calculating the strength of a single-riveted joint, we must know—*First*, what the tensile strength of the iron or steel plate is, from tensile test; *second*, the diameter and pitch of the rivets; and *third*, the resistance to shearing per square inch of the material of which the rivets are made. On this latter requirement there has been no little discussion. It was formerly assumed, when only iron plates and iron rivets were used, that the shearing resistance of a square inch of rivet was equal to the tensile strength of a square inch of the rivet itself, or of the plate. That is, if we have iron of a tensile strength of 45,000 lb. per square inch, the shearing resistance of a square inch of rivet would be 45,000 lb. On this assumption it would be only necessary to so arrange the diameter and pitch of rivets that the area of rivet or rivets to be sheared should exactly equal the net section of plate to secure a perfect joint. Later experiments, together with improvements in the manufacture of iron, and the introduction of steel, have changed these conditions relatively. While the shearing resistance of rivets per square inch has been, and even to-day is, by many assumed to be 45,000 lb. per square inch, the assumption has arisen, no doubt, from the fact that the rivets rarely shear. I have examined many exploded boilers, and the fractures have almost invariably been through the solid plate or along the line of rivets. It is very rare that the rivets shear. This, no doubt, arises from the fact that the pitch of the rivets was out of proportion to the net section of plate. The old rule seemed to be, the more rivets, the stronger the joint. There was, no doubt, a desire on the part of the boiler makers to make a tight joint, and they thought that if they pitched the rivets wider it would be difficult to calk the joint so that it would be steam and water tight. One would quite naturally assume that steel plates should be riveted with steel rivets, but such is not the usual practice. Most of the boilers now constructed in this country are made of steel plates, and they are largely riveted with iron rivets. In this country there have been comparatively few experiments on the strength of riveted joints made of steel plates and steel rivets, and as the general practice is to use iron rivets with both iron and steel plates, I confine myself here to the discussion of the iron rivet. I will say, however, that in England very careful experiments have been made, and a large percentage of strength is given to steel rivets over iron rivets. The details of these experiments can be found in *Wilson on Steam Boilers*, and particularly, and very full in detail, in *D. K. Clark's recent work on Steam Engines and Steam Boilers*. When the true value of the steel rivet is fully decided, and its use becomes general in this country, that value can be easily substituted for the value of iron rivets in the calculations of the strength of riveted joints, the other elements in the problem remaining the same. What value then shall we give to the iron rivet when used in connection with steel or iron plates? In settling this question I have not only been aided by the experiments of English engineers, but I have availed myself of the results of experiments made on the large Emery testing machine at the U. S. Arsenal at Watertown, Mass. These experiments have been made with American iron and steel, and hence will be valuable to us all in our practical work in this country. In a series of five experiments with steel plates and iron rivets, holes punched, the shearing resistance per square inch was as follows: 39,740 lb., 38,190 lb., 36,770 lb., 38,636 lb., and 41,100 lb. In view of these results, and other similar experiments, I assume 38,000 lb. per square inch as a safe estimate of the single shearing resistance of iron rivets in steel plates. Later experiments may change these figures slightly. In these experiments the steel plate was 55,000 lb. tensile strength per square inch. Assuming then 38,000 lb. as the safe estimate, we must decide upon the thickness of plate, diameter of rivet hole and pitch of rivets. In deciding upon these elements in the problem we must so adjust the size and pitch of rivets as to make the shearing resistance of the rivets as near the strength of net section of plate as possible. I will assume the elements of the problem to be as follows:

Steel plate, tensile strength per square inch of section, 55,000 lb.
Thickness of plate, 5-16 in. = decimal 0·3125.
Diameter rivet holes, 13-16 in. = decimal 0·8125.
Area of rivet hole = decimal 0·5185.
Pitch of rivets, 1 7-8 in. = decimal 1·875.
Shearing resistance of iron rivets per square inch = 38,000 lb.
Then $1.875 \times 0.3125 \times 55{,}000 = 32{,}226$ lb. = strength solid plate.
$(1.875 - 0.8125) \times 0.3125 \times 55{,}000 = 18{,}262$ lb. = strength net section of plate.
$0.5185 \times 38{,}000 = 19{,}703$ lb. = strength of one rivet in single shear.
Net section of plate is the weakest; therefore:
$18{,}262 \div 32{,}226 = 56.6$ per cent. efficiency of joint.

DOUBLE RIVETED JOINT.

In double riveted joints we find an accession of strength over the single riveted joint of nearly 20 per cent. This arises from the wider lap and the better distribution of the material. The rivets are pitched wider, and there is more rivet area to be sheared together, with a larger percentage of net section of plate to be broken.

Steel plate, tensile strength per square inch of section, 55,000 lb.
Thickness of plate $\frac{3}{8}$ in. = decimal 0·375.
Diameter rivet holes $\frac{15}{16}$ in. = decimal 0·9375.
Area rivet hole = decimal 0·69.
Pitch of rivets $3\frac{1}{16}$ in. = decimal 3·0625.
Shearing resistance of iron rivets per square inch, 38,000 lb.
Then $3.0625 \times 0.375 \times 55{,}000 = 63{,}164$ lb. = strength of solid plate.
$(3.0625 - 0.9375) \times 0.375 \times 55{,}000 = 43{,}828$ lb. = strength net section of plate.
$0.69 \times 2 \times 38{,}000 = 52{,}440$ lb. = strength of two rivets in single shear.
Net section of plate is the weakest; therefore:
$43{,}828 \div 63{,}164 = 69.3$ per cent. efficiency of joint.
70 per cent. is usually assumed in practice.

TRIPLE RIVETED JOINT.

In a triple lap riveted joint, we still gain in strength for reasons similar to those above.

Steel plate, tensile strength per square inch of section, 55,000 lb.
Thickness of plate $\frac{3}{8}$ in. = decimal 0·375.
Diameter rivet holes $\frac{13}{16}$ in. = decimal 0·8125.
Area one rivet hole = decimal 0·5185.
Pitch of rivets $3\frac{1}{4}$ in. = decimal 3·25.
Shearing resistance of iron rivets per square in., 38,000 lb.
Then $3.25 \times 0.375 \times 55{,}000 = 67{,}031$ lb. = strength of solid plate.
$(3.25 - 0.8125) \times 0.375 \times 55{,}000 = 50{,}273$ lb. strength net section of plate.
$0.5185 \times 3 \times 38{,}000 = 59{,}109$ lb. strength of three rivets in single shear.
Net section of plate is the weakest; therefore:
$50{,}273 \div 67{,}031 = 75$ per cent. efficiency of joint.

DOUBLE WELT BUTT JOINT.

We now come to the double welt butt joint, triple riveted. I have selected this joint because we use it in practice where boilers of large diameters and high pressures are required. In the double welt joint a new element comes into the problem, viz., that of rivets in double shear. The inner welt is broader than the outer welt, and extends far enough beyond the former to enable us to introduce a third row of rivets, which are in single shear, but also are in double pitch. This increases the net section of plate and also adds another rivet to be sheared. All the other rivets are in double shear. The question now arises, What is the value of a rivet in double shear? We have assumed heretofore that the value of a rivet in single shear was 38,000 lb. per square inch. Now can we assume that the same rivet in double shear has twice the value that it did in single shear? It has been assumed by some writers that such is the case, and up to this time most engineers allow a double value to rivets in double shear. But the conditions are different from those of rivets in single shear. In the former the rivet is sustained by the plates above and below, while in single shear the resistance is confined to one point. An examination of the sheared sections of rivets in single shear usually discloses a slight elongation in the direction of the force applied. The experiments on rivets in single shear, and from which we get our data, have almost always been made on single riveted joints, with narrow strips of iron, as shown in the following Fig. 4.

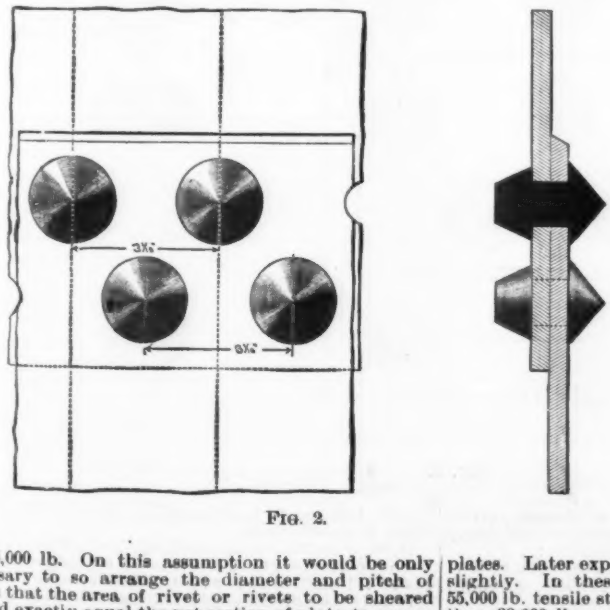


FIG. 2.

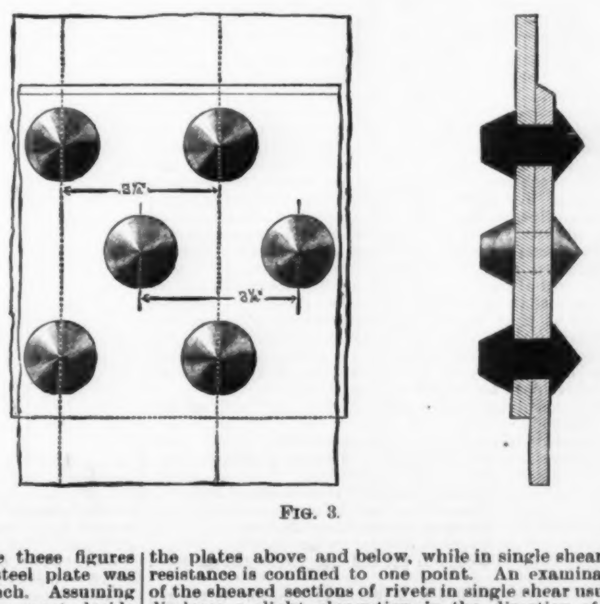


FIG. 3.

PASSAGES OF PRINCIPAL ATLANTIC PASSENGER STEAMERS (QUEENSTOWN AND NEW YORK), SEASON 1890.

[Specially Compiled from Official Logs.]—*From Engineering.*

NAME	"CITY OF PARIS."*	"CITY OF NEW YORK."	"MAJESTIC."	"TEUTONIC."	"ETRURIA."	"UMBRIA."	"CITY OF ROME."
Owners	Inman and International Line.	Inman and International Line.	White Star Line.	White Star Line.	Cunard Line.	Cunard Line.	Anchor Line.
Builders	Messrs. Thomson, Clydebank.	Messrs. Thomson, Clydebank.	Messrs. Harland & Wolff, Belfast.	Messrs. Harland & Wolff, Belfast.	Fairfield Company, Govan.	Fairfield Company, Govan.	Barrow Company.
Dimensions	560 ft. by 63 ft. by 42 ft.	560 ft. by 63 ft. by 42 ft.	582 ft. by 57¾ ft. by 59½ ft.	582 ft. by 57¾ ft. by 59½ ft.	501½ ft. by 57.2 ft. by 38.2 ft.	501½ ft. by 57.2 ft. by 38.2 ft.	546 ft. by 52 ft. by 58¾ ft.
Tonnage‖	10,499	10,499	9861	9686	8120	8128	8141
Displacement	13,000	13,000	12,000	12,000	10,500	10,500	11,230
Cylinders	Two 45 in., two 71 in., two 113 in.	Two 45 in., two 71 in., two 113 in.	Two 43 in., two 68 in., two 110 in.	Two 43 in., two 68 in., two 110 in.	One 71 in., two 105 in.	One 71 in., two 105 in.	Three 46 in., three 86 in.
Piston stroke	5 ft.	5 ft.	5 ft.	5 ft.	6 ft.	6 ft.	6 ft.
Boiler heating surf.	50,265 sq. ft.	50,040 sq. ft.	40,972 sq. ft.	40,972 sq. ft.	38,817 sq. ft.	38,817 sq. ft.	29,286 sq. ft.
Grate area	‡1293 ,,	†1089 ,,	1184 ,,	1184 ,,	1606 ,,	1606 ,,	1398 ,,
Steam pressure	150 lb.	150 lb.	180 lb.	180 lb.	110 lb.	110 lb.	90 lb.
I.H.P.§	18,260	15,160	18,000	18,000	14,300	14,301	11,890

Details of westward passages—to New York.

"City of Paris."

Month.	Time.	Distance.	Average Speed per Hour.
1889.*	d. h. m.	knots	knots
May 1 ..	5 23 7	2865	19.95
,, 30 ..	6 5 17	2844	19.05
June 27 ..	6 20 15	2916	17.75
July 25 ..	5 23 10	2775	19.38
August 21	5 19 18	2788	20.01
Sept. 18 ..	6 0 16	2785	19.31
October 16	6 6 32	2777	18.47
Nov. 13 ..	6 5 12	2789	17.66
Dec. 11 ..	7 4 3	2816	16.36
Average ..	6 6 13	—	18.77

Fastest day's run, 515 knots in voyage of May 30.

"City of New York."

Month.	Time.	Distance.	Average Speed per Hour.
1890.	d. h. m.	knots	knots
May 8 ..	6 5 8	2839	19.44
June 5 ..	6 8 21	2866	18.99
July 3 ..	6 7 49	2897	19.08
August 7	5 12 7	2791	19.64
Sept. 4 ..	6 0 21	2779	19.25
October 2	5 21 19	2775	19.63
,, 30	6 7 3	2773	18.29
Nov. 27 ..	6 21 45	2795	16.88
Average ..	6 5 44	—	18.91

Best day's run, 502. This vessel, in March, 1891, exceeded 500 knots on four days, her passage being 6 days 2 hours 10 minutes, distance 2895 knots, average 19.74 knots.

"Majestic."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
May 1 ..	6 5 20	2848	19.07
,, 29 ..	6 4 45	2848	19.12
June 26 ..	6 4 40	2845	19.14
July 24 ..	5 22 56	2848	19.86
August 21	5 21 21	2784	19.56
Sept. 18 ..	5 21 30	2780	19.64
October 16	6 1 12	2782	19.17
Nov. 13 ..	6 6 15	2783	17.37
Average ..	6 2 8½	—	19.13
	0 0 3½		
	6 2 12	—	19.12

NOTE.—Last two passages being timed from Daunt's Rock, add 16 min. in each case, which increases the average by 3½ min.

"Teutonic."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
May 15 ..	6 14 9	2878	18.2
June 12 ..	6 7 45	2807	18.60
July 10 ..	5 21 56	2808	20.
August 7	5 19 5	2806	20.18
Sept. 4 ..	5 20 54	2774	19.69
October 2	5 22 19	2779	19.53
,, 30	6 13 21	2775	17.64
Nov. 27 ..	7 6 25	2781	15.95
Average ..	6 6 44	—	18.76

Best day's run, 512 knots. The August passage is the present record = 20.18 knots an hour.

See LETTERS, pages 48, 68, 112, 317, 442, 495.

"Etruria."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
May 10 ..	6 17 10	2874	17.8
June 7 ..	6 12 16	2872	18.0
July 5 ..	6 6 57	2865	18.8
August 2	6 10 22	2842	18.4
,, 30	6 8 33	2797	18.3
Sept. 27 ..	6 12 18	2793	17.8
October ..	6 10 38	2898	18.2
November	6 8 18	2724	18.3
Average ..	6 10 47	—	18.2

Best day's run, 481 knots in June.

"Umbria."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
May 24 ..	6 12 50	2862	18.3
June 21 ..	6 9 29	2872	18.7
July 19 ..	6 19 46	2836	17.3
August 16	6 3 21	2835	19.2
Sept. 13 ..	6 9 27	2798	18.1
October 11	6 15 41	2792	17.5
November	6 22 58	2791	16.6
December	6 18 57	2790	17.1
Average ..	6 14 12	—	17.85

Best day's run, 498 knots in August.

"City of Rome."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
April ..	7 15 0	2352	15.53
May ..	7 7 36	2811	16.00
July ..	7 7 37	2839	16.11
August ..	6 23 40	2776	16.55
Sept. ..	7 6 11	2779	16.52
October ..	7 3 14	2776	16.21
Average ..	7 5 33	—	16.16

Best day's run, 424 knots in August.

Details of eastward passages—to Queenstown.

"City of Paris."

Month.	Time.	Distance.	Average Speed per Hour.
1889.*	d. h. m.	knots	knots
May 15 ..	6 0 29	2894	20.03
June 12 ..	6 2 46	2884	19.66
July 10 ..	6 19 14	2928	17.94
August 7	5 23 38	2792	19.44
Sept. 4 ..	6 3 58	2788	18.84
October 2	5 23 54	2785	19.37
,, 30	5 22 57	2777	19.42
Nov. 27 ..	6 0 54	2789	19.25
Dec. 25 ..	5 22 50	2784	19.49
Average ..	6 2 33	—	19.27

Mean speed of all passages, **19.02 knots.**

"City of New York."

Month.	Time.	Distance.	Average Speed per Hour.
1890.	d. h. m.	knots	knots
May 21 ..	6 5 25	2920	19.16
June 18 ..	6 8 58	2932	19.17
July 16 ..	6 10 22	2913	18.88
August 20	6 0 40	2785	19.25
Sept. 17 ..	5 23 14	2773	19.36
October 15	6 2 27	2776	18.94
Nov. 12 ..	6 1 13	2780	19.14
Dec. 10 ..	6 1 26	2792	19.2
Average ..	6 4 5	—	19.12

Mean speed of all passages, **19.08 knots.**

"Majestic."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
May 14 ..	6 10 10	2896	18.79
June 11 ..	6 0 7	2866	18.85
July 9 ..	6 11 2	2889	18.48
August 6	6 5 43	2815	18.40
Sept. 3 ..	5 23 16	2810	19.02
October 1	6 4 39	2800	18.93
,, 29	6 7 0	2810	18.61
Nov. 26 ..	6 4 0	2811	19.00
Average ..	6 6 21	—	18.88

Mean speed of all passages, **19.06 knots.**

"Teutonic."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
May 28 ..	6 14 30	2936	18.46
June 25 ..	6 12 55	2890	18.42
July 23 ..	6 8 0	2879	18.94
August 20	6 2 45	2796	19.05
Sept. 17 ..	5 23 34	2796	19.46
October 15.	5 23 54	2783	19.34
Nov. 12 ..	6 4 5	2785	18.72
Dec. 10 ..	6 1 57	2789	19.11
Average ..	6 5 27	—	18.93

Mean speed of all passages, **18.84 knots.**

"Etruria."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
April 29 ..	6 12 19	2913	18.6
May 24 ..	6 20 6	2890	17.6
June 21 ..	6 10 50	2882	18.6
July 19 ..	6 10 13	2873	18.6
August 16	6 9 22	2872	18.7
October 11	6 10 28	2813	18.2
November	6 8 45	2880	18.6
December	6 10 41	2818	18.2
Average ..	6 11 36	—	18.38

Mean speed of all passages, **18.29 knots.**

"Umbria."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
May 10 ..	6 10 52	2919	18.8
June 7 ..	6 15 4	2942	18.5
July 5 ..	6 14 30	2923	18.4
August 2	6 12 16	2901	18.5
,, 30	6 13 48	2880	17.8
Sept. 27 ..	6 8 4	2825	18.6
October ..	6 9 39	2823	18.4
November	6 6 30	2804	18.6
Average ..	6 11 27	—	18.45

Mean speed of all passages, **18.15 knots.**

"City of Rome."

Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots
May ..	7 4 15	2853	16.56
June ..	7 11 58	2837	15.76
July-Aug.	7 5 52	2823	16.23
Aug.-Sep.	6 22 30	2787	16.73
Sept. ..	7 0 59	2782	16.46
October ..	7 11 11	2777	15.49
Average ..	7 5 37	—	16.2

Average speed of all passages, **16.18 knots.**

* As the City of Paris was not running in 1890, we have, for the sake of comparison, taken the figures for 1889. The June-July passages were lengthened owing to the stokers' strike requiring inexperienced men to be employed, and in the outward voyage of December very stormy weather was experienced, as indicated by the log given elsewhere. If the June and December passages were deducted the average outwards would be 6 days 1 hour 32 minutes, 19.20 knots per hour, while homewards with the July passage deducted, the average passage is 6 days 0 hours 40 minutes, 19.48 knots an hour. The average speed of all the ordinary passages was, therefore, 19.31 knots an hour.

† The City of New York was fitted in July, 1889, with a movable and self-cleaning grate, the patent of Mr. Thos. Henderson, Liverpool, and the grate area reduced to 1089 square feet, at which it remained till end of 1890. By renewals it has been increased to 1098 square feet.

‡ The introduction of Howden's system of forced draught has resulted in the shortening of the firebars by 13 in., bringing the firegrate area to 1098 square feet.

§ The indicated horse-power of City of Paris and City of New York as given is the best sustained, that of the Teutonic and Majestic is approximated, but we understand the vessels do not maintain the full 18,000 indicated horse-power.

‖ The tonnage of each vessel is from Lloyd's Register.

And it is reasonable to assume that there is a slight tendency in the rivet to lean in the direction of the force applied, which would account for the slight elongation of the sheared section in that direction. An examination of the sheared sections of rivets in double shear shows little or no elongation. The rivets being supported by the plates above and below, the shear is direct and the section is normal in form. Experiments made by the English Admiralty with ⅜ in. rivets showed that the double shear was about 90 per cent. stronger than the same diameter of rivet in single shear. Chief Engineer Shock, U. S. N., found by experiment that the resistance of bolts of iron to single shear was 40,700 lb. per square inch, and in double shear 75,300 lb. This gives an increase of strength of 85 per cent. The results of numerous experiments, both in this country and in Europe, show the resistance to double shear to be from 85 to 90 per cent. greater than the same rivets in single shear. From the foregoing I assume 85 per cent. as a fair and safe estimate of the excess of strength of rivets in double shear over those in single shear. We have already assumed that the resistance of rivets per square inch to single shear is 38,000 lb. If we add to this 85 per cent., we shall have 70,300 lb. as the safe estimate of the resistance of iron rivets per square inch to double shear. Further experiments may change these figures slightly. But I regard them as safe for use in all places where joints riveted with iron rivets are used. The use of the double welt butt joint in the construction of boilers is becoming quite common. This arises from the use of boilers of much larger diameter than those formerly used, and also the necessity

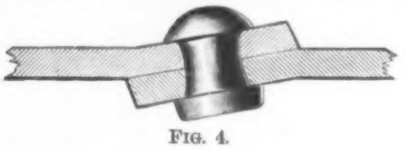


FIG. 4.

of higher pressures on account of the introduction of compound engines. With larger diameter and higher pressures, we find ourselves confronted with a very important problem. We must keep within the bounds of safety. For these huge vessels are very destructive to life and property if we disregard the importance of good material, good workmanship, and the well established factors of safety. It is not always safe to assume the highest results obtained by experimental tests. There will always be those who will insist upon higher pressures than safe rules will allow. Hence it becomes important that consulting engineer shall thoroughly understand the principles of safe construction, and not allow himself to be moved in his judgment when the question of safety is involved. We will now apply the above data to the following problem:

Steel plate, tensile strength per square inch of section 55,000 lb.

Thickness of plate ⅜″ = decimal 0·375.

Diameter of rivet holes 13/16″ = decimal 0·8125.

Area of rivet hole = decimal 0·5185.

Pitch of rivets in inner rows 3¼″ = decimal 3·25.

Pitch of rivets in outer rows 6½″ = decimal 6·5.

Resistance of rivets in single shear, 38,000.

Resistance of rivets in double shear, 70,300.

$6·5 \times 0·375 \times 55,000 = 134,062$ lb. Strength of solid plate.

$(6·5 - 0·8125) \times 0·375 \times 55,000 = 117,304$ lb. Strength of net section of plate at A B.

$0·5185 \times 4 \times 70,300 = 145,802$ lb. Strength of four rivets in double shear.

$0·5185 \times 38,000 = 19,703$ strength of one rivet in single shear.

This last result must be added to the strength of four rivets in double shear— thus $145,802 + 19,703 = 165,505$, shearing strength of all the rivets. The net section of plate is the weakest—therefore, $117,304 \div 134.062 = 87·5$ per cent. efficiency of joint. It will no doubt be observed that the strength of rivets in this joint is largely in excess of the strength of net section of plate, and the question will arise, Why increase the width of the inner covering strip and add two more rivets? As stated above, this was done to increase the net section of plate at A B, and thus increase the efficiency of the joint. If the inner welt or covering strip had been of the same width as the outer one, the net section of plate would have been greatly reduced and the differ-

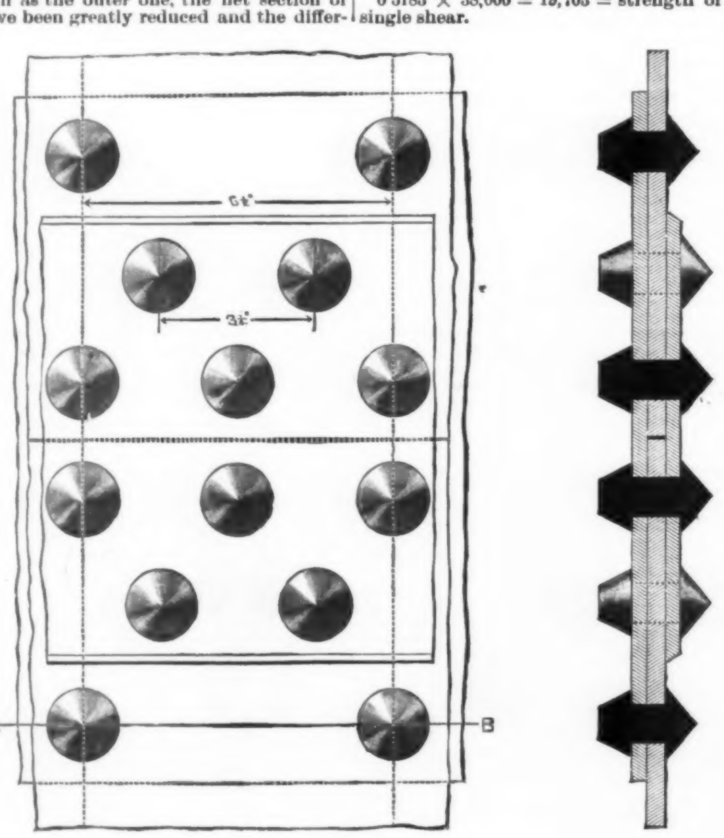


FIG. 5.

ence of strength between net section of plate and rivets would have been greater, thus reducing the efficiency of joint. The problem would be as follows:

$6·5 \times 0·375 \times 55,000 = 134,062$ = strength of solid plate.

$(6·5 - 0·8125 \times 2) \times 0·375 \times 55,000 = 100,546$. Strength of net section of plate.

$0·5185 \times 4 \times 70,300 = 145,802$. Strength of four rivets in double shear. Net section of plate is the weakest—therefore, $100,546 \div 134,062$ = only 75 per cent. efficiency of joint.

Again, it may be suggested—why not dispense with one row of rivets in double shear, and extend the inner welt or covering strip so that an outer row of rivets in double pitch and single shear could be used, thus increasing net section of plate as in the original problem, but reducing at the same time the shearing resistance of the rivets? The solution of this problem would be as follows:

$6·5 \times 0·375 \times 55,000 = 134.062$. Strength of solid plate.

$(6·5 - 0·8125) \times 0·375 \times 55,000 = 117,304$. Strength of net section of plate.

$0·5185 \times 2 \times 70,300 = 72,901$ = strength of two rivets in double shear.

$0·5185 \times 38,000 = 19,703$ = strength of one rivet in single shear.

This last result must be added to the result of two rivets in double shear.

$72,901 + 19,703 = 92,604$ = strength of all the rivets.

The total strength of rivets is the weakest—therefore $92,604 \div 134,062$ = 69 per cent. efficiency of joint.

It may be further suggested that a rivet of smaller diameter could be used. I will say that I have also considered such a problem, but have come to the conclusion that the joint, as illustrated and described, for efficiency and freedom from leaks, is the best. I will say here that a joint of this description was carefully

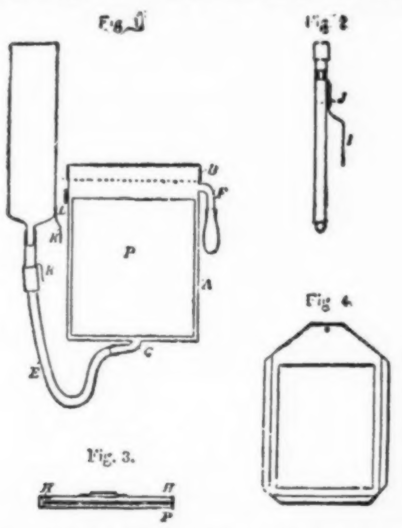
made and tested on the Emery machine at the United States Arsenal at Watertown, Mass. The result of the test was within two-tenths of one per cent. of the calculation made, and the line of fracture was through the net section of plate at the outer row of rivets, as we had predicted. It may be interesting to you to know that the company with which I am connected has between forty and fifty thousand boilers under its care and the risk involved is one hundred and fifty millions of dollars. Hence we cannot be too careful in our calculations of the strength of boilers. We employ one hundred and twelve men as inspectors, who are constantly at work examining this large number of boilers.

In conclusion I will say, thoroughly understand whatever you undertake to do. The technical school furnishes for you the underlying principles of your profession. The superstructure must be mainly your own work. Grave responsibilities will rest upon you when you become established in your life work. It is a glorious age to live in, and he who by honesty and industry does his part well, will not fail of his reward.

DEVELOPING WITHOUT A DARK ROOM.

AT a recent meeting of the Liverpool section of the Society of Chemical Industry, Mr. Alexander Watt described an apparatus which he has devised for developing without a dark room. It consists of a metallic case, A (Fig. 1), only slightly larger than the plate for which it is intended, which can be closed light tight by means of the lid, B. It is furnished with two tubes, one, C, entering at the bottom of the bath, which can be connected by a piece of India rubber tubing, E, to the funnel, D; the other is near the top, just above the level of the plate, P. The former serves to introduce the developer into the bath, and the latter, F, allows the air to escape and also acts as an overflow.

The funnel, D, and the India rubber tube, E, are supported by means of the hooks, K K, which fit into the eye, L. The tubes are so bent that no light can enter the bath. An end view of the bath is shown in Fig. 2, in which a movable hook, I, fitting into the socket, J, serves to fix the bath to any convenient support. A section, Fig. 3, shows the plate, P, the film side of which is kept from contact with the side of the bath



by means of the metallic strips, H. When the bath is intended for the development of films or paper prints, it is furnished with a carrier (Fig. 4), into which the film or paper is inserted before being put into the bath, and when required for the development of several plates at one time, it is constructed with grooves, as in an ordinary plate box.

The bath is used as follows: The dark side containing the exposed plate and the bath are placed in a changing bag, into which it is only necessary to insert the hands. The plate is then transferred from the slide to the bath, care being taken to keep the film side toward the back of the bath. After being closed, the bath is withdrawn from the bag into daylight, and fixed vertically to any convenient support by means of the hook. A vessel is placed under the overflow tube, and the inlet tube is attached to the funnel, which, after being filled with the developing solution, is raised and lowered several times, to alternately fill and empty the bath, and so insure the removal of air bells from the surface of the plate. After standing sufficient time to complete the development, the solution is run off from the bath. The plate is washed by running water through the bath (either by means of the funnel or by attaching the India rubber tube direct to a water tap), after which it is taken out in daylight, and "fixed" in a covered tray. If it be desired to "fix" entirely in the dark, the operation may be conducted in the same bath, or in a similar one to which the plate has been transferred in the changing bag. The final washing of the plate may be done either in the bath or in the usual way.

The best developer for use with the dark bath is ferrous oxalate, on account of its property of not producing "fog," even when a plate has been left in it for an hour. It should be made just before use from the following solutions, prepared according to Thomas' formulæ—

No. 1.

Potassium oxalate....	300	grms.
Potassium bromide........	2.2	"
Water to make....................	1,000	c. c.

No. 2.

Ferrous sulphate................	400	grms.
Sulphuric acid....................	3	c. c.
Water to make....................	1,000	c. c.

To 4 parts of No. 1, add 1 part of No. 2, and water to make 8 parts.

When the developer is used at once with Thomas' "Extra Rapid" plates, from 12 to 15 minutes in the bath at about 15° C. is sufficient to give a satisfactory negative, if the exposure has been correct. The time required to obtain a suitable density is found by placing the exposed plate in the bath and adding the amount of developer required to fill the bath, in four equal portions, at intervals of five minutes. Four densities are thus obtained by developing for 5, 10, 15, and 20 minutes respectively, from which observations the time that gives the desired density is selected. —*The Chem. and Drug.*

SMOKE AND FUMES ANNIHILATOR.

WE paid a visit a few days ago to the works of Messrs. Manning, Wardle & Co., Leeds, for the purpose of inspecting Elliott's smoke and fumes annihilator, which this firm has in operation in connection with their boilers. The machine entirely differs from anything hitherto attempted in the direction of solving the problem of smoke abatement. The idea of

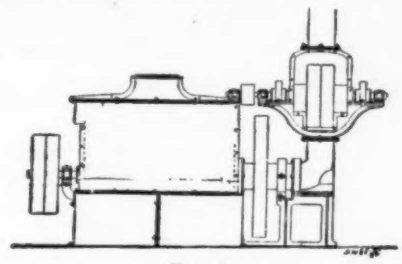


FIG. 1.

washing smoke appears at first somewhat peculiar, but that such a thing can be successfully accomplished is demonstrated beyond a doubt by the machine in question. The accompanying illustrations will greatly assist our readers to understand the nature of the invention. Fig. 1 gives a front view of the mechanism, and Fig. 2 the same view, with the addition of the flue and chimney. The apparatus consists of an exhaust fan (shown in the upper right-hand corner of Fig. 1), and a washing machine and annihilator. The smoke and fumes from the boiler are drawn from the back flues by the exhaust fan, and passed into the annihilator, and the vapor escapes into the chimney, as shown in Fig. 2. The annihilator is the tank shown to the left of Fig. 1. This tank is fitted with a hollow perforated spindle, revolving horizontally, and carrying perforated paddle blades, and several curved baffle plates are placed above the paddle blades. The tank is charged with water at the bottom to a level of one or two inches below the under side of the perforated hollow spindle. The smoke and fumes enter the tank through the perforations in the hollow revolving spindle, and a fine spray is raised in the upper part of the tank by the paddle blades dashing through the water. The smoke and fumes become beaten up in this spray and against the baffle plates, the result being that all carbon, dust, and other matters in suspension in the smoke and fumes are arrested, and the sulphur and other gases that are soluble in water are absorbed, thus leaving a pure white vapor to pass away into the air. Such is a brief description of the machine, and the question is, Does it answer its description? We have no hesitation in saying it does. We had the machine shown to us in operation under various conditions, the result being equally satisfactory in every case. First, we inspected a machine provided for the purpose of showing its mechanism; then a small one affixed to a vertical boiler and engine, with the annihilator inoperative. The smoke was allowed to ascend in the usual black volume, which was speedily changed to a white vapor upon the annihilator being set in motion. Some may remark that this may do very well in the case of a small boiler, where no great volume of smoke has to be contended with, but what is the result with the largest factory boilers? This we had demonstrated to us, and found the result the same. In a third machine, we had the opportunity of noticing the nature of the scum or refuse thrown off during

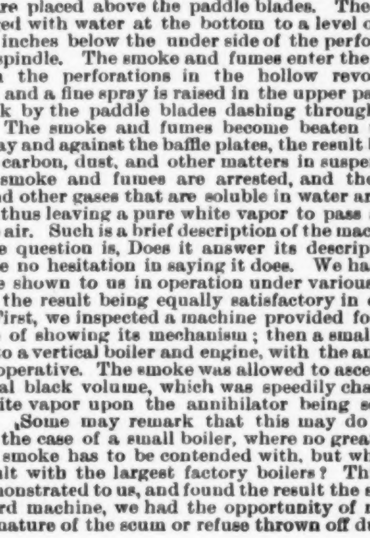


FIG. 2.

the process of washing the smoke. Each machine is inclosed and proper facilities offered for removing the scum, but, in the present case, the top of the tank was removed and quantities of the scum were allowed to escape into a trough placed in a convenient position. To those who have not studied the subject of smoke abatement, the amount of black vapor found in the former, as demonstrated in the present instance, would come as a great surprise. From this residuum, byproducts are recovered of such a character as to be of commercial value, and most users of the annihilator will, at least, be able to utilize the residuum as a fertilizer, although it is valuable for electrical and other purposes of a higher grade. The patentee claims for the invention that it will not only abate but entirely prevent smoke being emitted from any chimney, together with the sulphurous and noxious fumes combined with smoke. The machine only occupies a few feet, and can be placed in any position, either within or outside a building, and can be attached either to existing machinery by a belt or worked by a separate engine of nominal power. The method of attachment to existing chimneys, shown in Fig. 2, is both simple and inexpensive, and the strong draughts created by the machine can be regulated as required. Besides this, chimneys are not necessarily needed so high as those at present in use, and the cheapest form of fuel can be used with good results, either by hand or by mechanical stoking. The cost of running an annihilator is not great, and what little expense there is can, it is considered, be counterbalanced by the value derivable from the residuum obtained in the process of washing the smoke. The favorable opinions expressed by scientific and other authorities are too numerous to quote here, but, perhaps, that to which our readers will pay most attention comes from Mr. C. W. Raymond, an inspector of factories, who says: "This machine will be of immense value to manufacturers, and I shall draw their attention to it."—*Textile Industries.*

[Continued from SUPPLEMENT, No. 810, page 12941.]

FAST AND FUGITIVE DYES.*

By Prof. J. J. HUMMEL.

THE ACTION OF MILLING ON COLORS.

NEXT, if not equal, in importance to the action of light is the consideration of the effect on dyed colors of those manufacturing operations to which the dyed materials must of necessity be submitted.

These vary considerably, according to the material, and without enumerating them, I propose first to direct your attention to that of "milling" or "fulling."

When a piece of woolen cloth leaves the loom, it has not, unfrequently, a coarse, sacklike appearance; quite intentionally, in order to obtain a certain quality of texture, the warp and weft threads have not been brought into closest contact with each other in the loom. This is only effected subsequently by the milling operation, which consists in squeezing and hammering the cloth, previously moistened with a little strong soap solution, in special forms of apparatus. During this operation, the threads and fibers are felted together, and the fabric gradually becomes more and more compact.

What, then, are the influences thus brought to bear upon the colors of the fabric, supposing these to have been previously imparted to the wool or yarn of which it is made?

First, there is the action of the slightly alkaline soap; the colors should not be dissolved off by it, nor destroyed, nor even materially impoverished or altered in hue.

Further, if the fabric is composed of variously colored yarns, as, for example, in tweeds, the colors must not "run" or "bleed," *i. e.*, the coloring matters of one set of threads, if at all removed, must not stain those of another set; white threads particularly must maintain their pristine purity, otherwise the pattern loses sharpness and decision, or the whole fabric appears soiled, and is thereby rendered quite unsalable. This difference in effect obtained by employing colors fast or fugitive to milling is well shown in the stripe and check patterns woven in our Yorkshire textile department, by my colleague, Prof. Beaumont.

The action of milling on dyed colors may be rapidly determined in the laboratory, by vigorously rubbing together, with strong soap solution, the dyed pattern and some white flannel. It is better still to stitch soft white woolen yarn into the dyed pattern, and then to submit it to the actual milling operation of the factory along with a large piece of white cloth.

On these two diagrams are patterns which have been milled in this manner; and on close examination they show how very differently the various classes of coloring matters behave when submitted to this operation. Fast to milling, especially with respect to bleeding, are all those phenolic coloring matters which can only be applied by means of mordants, *e. g.*, alizarin, cœrulein, fustic, logwood, etc. Why do those colors not bleed? Because in the dyed fibers the coloring matters form, in combination with the mordant, an insoluble precipitate, which is largely inclosed within the substance of the fiber. That portion of the precipitate which lies on the surface is undoubtedly removed mechanically during the milling process; but even then, since the coloring matter is combined with the mordant, and is not in the free state, it cannot combine with the mordants of neighboring dyed fibers, nor can it be attracted by and stain unmordanted white fibers.

I would, however, specially draw your attention to the fact that even this class of "mordant dyes," as I have termed them, are liable to bleed in milling, if they are improperly applied.

Allow me to reiterate that, in the case before us, the development of color during the dyeing process is due to a chemical combination taking place between the coloring principle of the dyestuff and the mordant. This being so, the colored pigment, lake, or precipitate, produced has a fixed chemical composition—a definite amount of coloring matter has combined with a definite amount of mordant.

It does happen, however, that the normal pigment at first produced within the fiber is capable of taking up in the dye bath a further amount of coloring matter, if the latter is employed in excess; the normal compound is, as it were, changed into a more acid compound.

Further, the wool fiber itself absorbs a certain small amount of coloring matter, which remains uncombined with the mordant. If, therefore, a deficiency of mordant or an excess of coloring matter has been employed in dyeing, the uncombined or loosely combined coloring matter will assuredly be removed during the milling process, and give rise to "bleeding."

How necessary it is, then, with dyes of this class, that mordant and coloring matter should be duly pro-

* A paper recently read before the Society of Arts, London.

portioned to each other, and yet how prevalent is the custom among dyers to mordant with a fixed amount of mordant, and to dye with the most varied amounts of coloring matter.

The practical dyer is apt to reply: "Ah! we are far from dyeing according to molecular weights yet." Quite true, and yet I would venture to say, in the language of Sir Frederick Bramwell, that these are some of the "next-to-nothings," attention to which will certainly distinguish the dyer of the future from the "rule-of-thumb" dyer of the past. Nay, even at the present time, the intelligent dyer cannot afford to ignore these little matters, or he will, ere long, find himself left behind in the race. But to return: so far as fastness to milling is concerned, it is better even to employ a slight excess of mordant than a deficiency, but of course it is best to determine by experiment, and to employ exactly that proportion of mordant which is best suited to each percentage of coloring matter employed.

In all cases it is advisable to fix, by what is known as the "saddening method," *i. e.*, by the application *after* the dyeing process, of a small amount of mordant, that remnant of coloring matter which the wool itself has absorbed.

Now let us pass on to the consideration of those coloring matters which dye wool *direct*, *i. e.*, without the aid of a mordant. How do these behave toward the milling process?

In many cases they are not fast. Since they dye without mordant, the little coloring matter, which invariably comes off during milling, readily dyes the whole fabric, staining the whites and soiling, more or less, all the pale shades of contiguous fibers.

Coloring matters allied in chemical constitution to magenta, the azo-scarlets, nitroso-compounds, and some other basic and acid coloring matters, nearly all bleed during milling. The dyed colors themselves, perhaps, are not materially impoverished, so that a plain dyed fabric might be milled with impunity, provided the soap used be of good quality, *i. e.*, not too alkaline; nevertheless such coloring matters are practically useless for tweeds and the like, where variously colored fibers are interwoven. It is interesting to note, however, that many even of the "direct dyes" are perfectly fast to milling.

Even among the triphenyl-methan colors, *i. e.*, those of the magenta group, there are a few specially remarkable exceptions to the rule, *e. g.*, Victoria blue and night blue. Members of the eosin group are also generally characterized by their fastness to milling, *e. g.*, cyanosin, phloxin, rose bengal, etc. Similarly fast is the phenolic coloring matter of orchil, and I must not forget another natural coloring mattter, viz., vat indigo.

Most noteworthy for fastness to milling is the whole group of "Congo colors," which we saw were generally so fugitive to light. These form a special class of azo colors, and it is in consequence of this fastness to milling, and the fact that they dye cotton *direct*, that, notwithstanding their generally fugitive character toward light, they have made such rapid progress commercially. It is well to add that this fastness to bleeding of Congo colors only refers to wool; any white cotton fibers in the fabric milled would certainly be stained.

Why do some of these direct dyes bleed and others not? One might be inclined to answer that those coloring matters which dye in an alkaline bath will probably bleed, since an alkaline condition prevails during milling. To some extent this explanation is satisfactory. Witness the general instability in this respect of the basic coloring matters; on the other hand, how shall we explain the remarkable fastness of the Congo colors which are also applicable in a slightly alkaline bath? Further, how explain, in this way, the fugitive character, as regards bleeding, of all those coloring matters which are only applied in an acid bath, and which, therefore, we should materially expect to be incapable of staining when in an alkaline condition?

A possible explanation, in some cases, at least, which occurs to me is, that those coloring matters which are fast to milling form very insoluble compounds with the substance of the wool fiber itself, which thus acts as it were as a mordant, and thus they are fixed as insoluble pigments within the fiber.

But to continue. Many "direct dyes," more particularly those which are applied to wool in an acid bath, have the defect of being greatly impoverished in color during milling, even to the point of total destruction apparently. Examples of this class are acid magenta, azo scarlets and oranges, indigo carmine, etc.

In the cases now referred to, the color is partly or entirely restored, by passing the milled piece through dilute sulphuric or acetic acid. The reason of this decolorizing action is very evident. The alkali of the soap has neutralized the "color acid" of the dyed fiber, and produced a pale colored, or even colorless, alkali salt of the color acid.

The restoration of the color during the subsequent passage through acid is due to the decomposition of the colorless alkali salt, with the liberation of the original highly colored color acid.

In illustration of this point, I here show you a sample of wool which has been dyed with the coloring matter known as alkali blue. Here is another sample, showing its appearance after it has been submitted to the milling process. The color has practically disappeared. As you now see, mere steeping in acid suffices to restore the color.

Some colors, both such as are dyed directly, or even with the aid of mordants, have the defect of being entirely altered in hue during milling. Cochineal scarlets become crimson, orchil purple becomes violet, turmeric yellow becomes brown, and so on. Here, again, the alkali of the soap either dissolves or decomposes the lake, or it combines with the coloring matter to form a differently colored compound.

Closely allied to action of milling is

THE ACTION OF SCOURING ON DYED COLORS.

When wool has been dyed in its loose, unspun condition, it is dried, and impregnated with oil to facilitate the carding and spinning processes. The yarn or cloth made from such dyed fiber has therefore to be submitted to the operation of scouring, in order to remove the oil of the spinner. It consists in washing the material in a warm solution (50°—60° C.) of soap or carbonate of soda, or a mixture of the two, until the oil is entirely removed. The stronger alkali and the higher temperature employed cause the operation of scouring to be even still more searching on dyed colors than that of milling. Those colors which are altered in hue, decolorized, or impoverished in color by milling are much more altered by scouring. Some—for example, Prussian blue—are entirely decomposed.

The high estimation in which wool-dyed cloth is so generally held is just because the dyes selected must be fast to the subsequent manufacturing operations to which I have referred. Still it is very unwise nowadays to depend upon such a factor as this, for a color may have passed untouched through these operations and yet be very fugitive to light or other influences.

Very susceptible to the action of scouring are the sulphonic acid colors, and, indeed, for the same reasons as were explained under the head of "milling." Fast to scouring, as a rule, are the mordant dyes, the eosins, Congo colors, and some others.

The destructive action of the scouring agent depends mainly, as I have said, upon the alkali it contains, and the temperature at which it is applied; hence all colored goods, whether in the manufactory, the public laundry, or the household, should be washed or scoured at a low temperature, and with a soap which is as neutral as possible.

Washing soda, in all its forms and under all its varied and alluring names, should be rigorously avoided.

ACTION OF STOVING ON DYED COLORS.

In some instances dyed colors must be fast to what is known as the operation of "stoving." Such is the case, for example, with those colored yarns which form the striped headings of blankets, with many kinds of woolen hosiery, etc.

In goods of this kind, white and dyed fibers are interwoven or even spun together, and the materials are submitted to a final bleaching with sulphurous acid, so that the white fibers, which may have become soiled during the spinning and weaving operations, shall ultimately appear in all their original purity.

Many "acid colors" and "mordant dyes" withstand this stoving operation, but others are more or less altered in color, or are entirely decolorized, either because the coloring matter is reduced, or the color lake is decomposed by reason of the acid vapors.

Some colors are so sensitive to the influence of sulphurous acid that they are altogether unsuitable for the air of towns, which is always more or less charged with this gas.

Such a color, for example, is manganese brown, the sensitiveness of which I can show you by steeping this pattern in a solution of sulphurous acid, when it is very rapidly bleached. Catechu brown, on the other hand, which I immerse simultaneously, is fast to this influence.

I may refer here to a color which is remarkable for its fastness to light and most influences, *e. g.*, acids, alkalies, etc, but which, especially in the early days of its production, gave a great deal of trouble and annoyance, just because of its sensitiveness to sulphurous acid. I refer to aniline black. Formerly, it was not unusual for large quantities of calico, printed or dyed with this color, to become utterly unsalable, because during storage in the town warehouses the outer folds all changed to a dull green color, and although washing with alkali restored the color somewhat, still it was always liable to turn green again. Eventually the defect was overcome by submitting the black prints to a supplementary oxidizing process, whereby the sensitive black was changed into a different black, far less susceptible to the reducing action of the sulphurous acid.

On one of the diagram sheets I have affixed dyed patterns, portions of which have been submitted to the action of sulphurous acid, and you see there how some are fast and others fugitive to this influence.

ACTION OF ACIDS ON DYED COLORS.

Fastness to acids is required from the colors on cotton yarn intended to be woven with white woolen or worsted weft, which is subsequently dyed with acid colors.

Further, the colors of all materials intended to be worn next the skin should be fast to acid, since perspiration contains such organic acids as acetic acid, butyric acid, etc; and although the acidity of perspiration is slight, indeed it is sometimes alkaline, still it can exercise considerable influence on dyed colors, in consequence of the additional action of friction and heat, and by its concentration upon the fiber. There are other cases in which dyed colors have to withstand acid influences, but at this late hour I will pass them by. Fast to acids are many of the "mordant dyes," and those colors which are dyed in an acid bath, provided the acidity is not too great. Basic colors, and most of the Congo colors, are very sensitive to acids. The sensibility of Congo red, for example, is already quite proverbial, so that it is even now recommended as an indicator rather than as a dye. I will show you the extreme sensibility of Congo red, and compare it with the fastness of alizarin red, by steeping these two patterns in dilute acid. There, you see, the Congo red becomes blue, the alizarin red remains unchanged.

Now let us consider briefly the question of

THE RUBBING OFF OF DYED COLORS.

No color can be considered fast in its most complete sense if it has this defect, and yet, strange as it may appear, one of our fastest dyes in all other respects is particularly unfortunate in this respect. I refer to vat indigo blue. Of defective coal tar colors in this respect, I may mention malachite green and Victoria blue; indeed, all the basic coloring matters show the defect more or less, especially if they are heavily dyed. Acid colors and Congo colors as a rule are free from the defect. On the other hand, even "mordant dyes" are liable to rub off if they are improperly applied. The use of mordant or dye solutions, which are too sensitive, *i. e.*, which are apt to decompose and precipitate before they have properly penetrated the fiber, should be avoided. It is an axiom in dyeing, that all coloring matters and mordants should be applied in a perfectly soluble form; further, the mordant should be thoroughly fixed upon the fiber, so that it does not bleed out into the dye bath, and thus give rise to muddy dye liquors. The immediate cause of rubbing off is the presence of loosely adhering insoluble pigment upon the surface of the dyed fiber.

Not unfrequently, in the case of wool, the fault is due to insufficient scouring, the employment of hard water, or from some similar cause. The fiber is permeated or coated with lime soap, or with grease in some form or other, which either fixes the dye upon the surface or prevents the effectual penetration of mordant or dye solution.

Under varying conditions of temperature, this grease is ever exuding, carrying with it coloring matter to the surface, where the oily mixture is ready to stain the white pocket handkerchief (by no means a flag of truce) applied by the merchant buyer.

But, apart from such general causes of rubbing off, there are cases where the defect is intimately connected with the nature of the coloring matter itself and its mode of application. Such, indeed, is the case with vat indigo blue. Let me briefly explain. Commercial indigo is an insoluble blue powder, and is the veritable substance which, in a somewhat purified form, the woad dyer aims at fixing on the fiber. In consequence of the fermentation set up in the woad vat, and the liberation of hydrogen, this indigo blue is changed into indigo white, which is soluble in the lime water of the vat. The indigo dyer steeps his fabric in the indigo white solution of the vat, and, when it has absorbed a sufficient quantity, it is passed through squeezing rollers and exposed to air. Oxidation of the absorbed indigo white at once takes place, insoluble blue is reproduced and precipitated upon and within the fiber. That portion of the indigo which is thus regenerated within the substance of the fiber cannot be otherwise than perfectly fast to rubbing off, but, since the squeezing process is imperfect, the fibers are covered with a comparatively large amount of superfluous vat liquor; this, too, oxidizes, so that each fiber has a quantity of indigo blue powder loosely adhering to its surface.

It is this portion of the dye, then, which rubs off, even though the scouring of the wool may have been absolutely perfect. How to remedy this inherent defect in a suitable and satisfactory manner is a practical difficulty not as yet thoroughly overcome.

From what I have now said, you will perceive how all-important it is that every dyer should know the sensibilities of his colors toward various influences.

It is by no means sufficient that he is merely able to match readily any given shade, that is a matter of course; such facility, in my opinion, is of little use, indeed it is worse than useless, for it is positively injurious, and partakes more or less of the nature of a fraud, if the coloring matters employed are not suited to the material dyed, and its ultimate purpose. The adequate fulfillment of these conditions alone constitutes good and creditable work. If it is true that a product of art should give us a glimpse of the life and character of the artist, so should it be with dyeing; every color with which a textile fabric is ornamented should at least reflect the honesty of purpose of the dyer.

Herein is a justification for the existence of our schools for dyeing, where our young craftsmen may be taught to "love, honor, and obey" the fundamental principles of their art, and where, by patient study and research, the numerous problems connected with the application of coloring matters may be solved, and then published, for the benefit of the whole community.

No one, certainly, wishes to buy a coat or a curtain that alters in shade in a month, or hosiery which marks off in the course of a summer day's walk, nor is it at all necessary that such defects should ever appear.

In justice to the dyer, however, I must exonerate him from the whole blame in such matters. No doubt he is sometimes insufficiently acquainted with all the properties of the dyes he employs; but his best intentions are often altogether marred or blotted out by the urgent demands of the merchant, who, in the eagerness of modern trade competition, wishes to buy and sell cheap.

Ever and anon we hear of the incomparable fastness of the colors of Indian art fabrics, tapestries, ecclesiastical garments, etc., belonging to past ages, when, I may remark, commercial competition was unknown; and the general public is led to believe that, not only has there been no progress in dyeing for a few centuries past, but that we have even made serious retrogression in the art.

If this were true, it would be indeed a sad reflection, that, with all the advantages of modern science, we are positively in a worse condition in this matter than in the times of the alchemists.

Happily it is not true, and I trust I have been able to show you this evening that there is no need to go back to the times of our forefathers to seek instruction in dyeing, and that we have among our modern coal tar dyes those which are as fast, and indeed in some instances faster, than any which have been employed in the past.

FORMOSA CAMPHOR.*

FORMOSA camphor is obtained from the *Laurus camphora*, immense forests of which extend over most of the lower ranges of hills in the island, extending up the lower slopes of the mountains inhabited by the savage tribes. Many of these forests have not been touched, and the statement that the camphor supplies in south Formosa are becoming exhausted applies only to those districts which are purely Chinese. The supply from other parts is practically inexhaustible. Even in purely Chinese districts it is only at certain places that the supply is falling off in consequence of the reckless manner in which the trees have been destroyed, partly for the sake of the timber and camphor, and partly, no doubt, simply to clear the ground for cultivation.

It has been often stated that the method of obtaining crude camphor in Formosa is by steeping the chopped branches in water, and boiling until the camphor begins to adhere to the stick used for stirring, when the liquor is strained, and by standing the camphor concretes. By this method it does not necessarily follow that the tree is destroyed; in fact, with a little care, there is no need that it should be. But although this method may have been in use in former days, it certainly is not now. On the contrary, I am assured by several natives, engaged in the trade, whom I have questioned on the subject, that the yield of camphor

* From a report by Mr. Consul Warren on the trade of Tainan, Formosa.

from the branches is too small to repay the labor of extraction.

The method in general use now is as follows: The camphor expert selects a tree and scrapes into the trunk in different places, using an instrument somewhat resembling a rake, with the view of ascertaining whether it contains sufficient camphor to repay the labor of extraction. A tree is said not to be worth anything for camphor purposes until it is fifty years' old, and the yield is very unequal; sometimes one side only of the tree contains enough camphor to satisfy the expert, and in this case that side alone is attacked. The trunk is scraped to as great a height as the workmen can conveniently reach, and the scrapings are pounded up and boiled with water in an iron vessel over which an earthenware jar, especially made for the purpose, is inverted. The camphor sublimes and condenses on the jar, which is removed from time to time, scraped, and replaced. The root of the tree and the trunk, for some eight feet up, contain as a rule the greatest quantity of camphor. If the scrapings obtained from the trunk yield well, the chipping is continued until in the end the tree falls. The roots are then grubbed up, as it is certain they will give a good return. If, however, the scrapings do not turn out well, the tree is abandoned, and work is commenced on another. No attempt is made to extract camphor from the fallen trunk or from the branches. In some cases the trunk is sawn up into timber, but this depends on the locality; from many districts, owing to the absence of roads, timber would not pay for its transport.

It is impossible to imagine a more wasteful method of procedure, and it is fortunate that the camphor forests of Formosa are practically inexhaustible.

The quantity of camphor produced depends, of course, simply on the amount of labor employed in the business. Ten of the iron pots mentioned above and their accompanying jars make up what is called a "set," and are worked by four men. One set will produce about 65 lb. in ten days, or, say, 1¾ cwt. a month, but this is only under the most favorable circumstances; a fair average is about 1¼ cwt.

Recently a change has been made in the camphor monopoly. It is now proposed by the Chinese authorities that the camphor stills should be licensed before they are permitted to work. The cost of the license will be equivalent to a tax of about 22s. 6d. per cwt., a heavy tax, seeing that the actual value of the camphor at the place of production is very little over this amount.

GIRAUD'S THERMO-ELECTRIC STOVE.

ALL the endeavors that have been made to convert thermic energy directly into electric energy have hitherto failed, in consequence of the indifferent rendering of thermo-electric batteries. In fact, if, in order to fix our ideas, we consider the most improved of our present gas thermo-electric piles, we find from the most recent experiments of Messrs. Carpentier & Uppenborn and of the author of this article that the consumption cannot descend below 30 liters per watt-hour, or 30 cubic meters per kilowatt-hour, a figure which, at Paris, would put the kilowatt-hour at 9 francs—a price six times higher than that paid at a maximum at the central stations of distribution. The thirty cubic meters of gas disengage, through their combustion, about 156,000 heat units, while the kilowatt-hour represents but 850. Therefore, scarcely one five-thousandth of the thermic energy of combustion is converted into disposable electric energy.

This figure, which appears to be prohibitory when the electric energy constitutes the essential element of production, has nothing of that character when, on the contrary, it is the production of heat that plays the most important part, and the electric energy may be considered as produced to boot, so to speak, the supplementary expense being represented solely by the interest and the amortizement of what is furnished complementary to the heating apparatus, which preserves its entire power and function. It is, therefore, not illogical to endeavor to construct a thermo-electric stove capable of furnishing both heat to rooms and a sufficient quantity of electric energy for the normal lighting of the same. Deeply impressed with this idea, Dr. Giraud, of Chantilly, has for several years been engaged in researches, which appear to us to be now crowned with success, and the results of which we shall briefly present to our readers.

Dr. Giraud's thermo-electric stove (shown in elevation in Fig. 1 and in longitudinal and horizontal section in Fig. 2) does not differ essentially, as regards appearance, from the apparatus that made the reputation of Mr. Choubersky.

As to characters in common, the two stoves have an elongated cylindrical form, are supplied with fuel at the top, are closed by a sand joint, and are mounted on casters. The differences reside in the mode of circulation of the gases, the regulation of the combustion by varying the opening of the ash pan, and especially in the jacket, which forms a circular sheath in which the elements of the thermo-electric battery are arranged. In the apparatus that we have seen in operation the elements were about seven hundred in number, arranged in twenty-five horizontal rows, which occupy the entire circumference for the entire height of the stove, save at the place reserved for the pipe that leads the products of combustion to the chimney. Each of these elements consists of a plate of nickel or tinned iron and of an alloy of antimony and zinc, with the addition of a few other metals in small proportion for the purpose of giving the alloy all the qualities of solidity, mechanical resistance, and durability that have hitherto been lacking in the majority of other thermo-electric elements. It is the studies of the best proportions of this alloy, the processes of rapid and economical moulding, and the mounting of the elements around the stove that constitute the principal merits of Dr. Giraud's labors on the question.

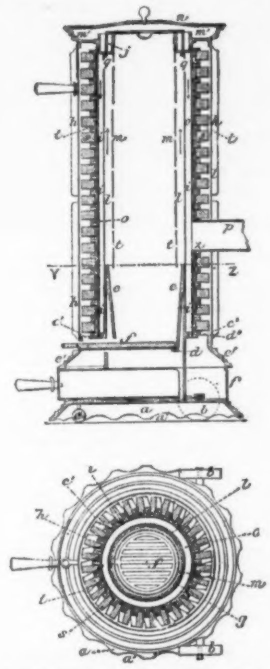


FIG. 2.—LONGITUDINAL AND HORIZONTAL SECTION OF THE THERMO-ELECTRIC STOVE.

b c, casters; *e*, fireplace; *f*, grate; *i*, jacket; *j*, cover with sand joint; *h*, coolers; *l*, space for the ascent of the gases; *o*, descent of the gases; *p*, pipe; *v*, spaces for the circulation of the air; *n*, open work cover through which the hot air escapes.

In order to insulate the elements from each other, and to prevent their direct contact with the hottest parts of the stove (which might lead to their fusion, or their rapid deterioration), the hot part of each element is covered with asbestos cloth and inclosed in a small iron plate box with a square base. All these juxtaposed and superposed boxes, the bottom applied against the cylindrical face of the stove, constitute a sort of hollow draught board in the squares of which are placed the 700 elements all mounted electrically in tension. The circulation of the gases is so arranged as to prevent an overheating of the lower rows, and yet assure a sufficient temperature to the upper ones, in order to equalize the electro-motive force of the elements. Without that, certain elements would be raised to an excessive temperature, a dangerous one even, while the others, hardly warm, would introduce into the circuit a resistance which would absorb through the passage of the normal current a difference of potential greater than their electro-motive force. The continuity of the envelope formed by the small iron plate boxes and the same mass of the elements assures an equalization of the temperature sufficient in practice to prevent too great differences in heating.

Now let us see the results. One of the stoves with nickel plates produces an electro-motive force of 40 volts and a current intensity, in short circuit, of four amperes. In the conditions of maximum effective power—and it is always in such conditions that a thermo-electric battery should operate, since its consumption is independent of its discharge—we can, therefore, obtain 40 disposable watts.

Such discharge corresponds to the full normal running. Upon reducing the draught, we diminish the consumption and lower the temperature, and the discharge may descend to 35, 30 or even 25 watts.

Every day, therefore, we may have at our disposal, according to the draught adopted, a quantity of electric energy equal to 800 or 1,000 watts-hour. The 30 or 40 watts furnished continuously by the battery would permit of supplying directly a ten or twelve candle lamp, and this is a solution that it would be possible to adopt in all cases where there would be no need of having more than one lamp lighted at once. In order to be able to supply several lamps simultaneously, to absorb the daily production in a few hours, and even to form a supply disposable at will, it will be preferable to use accumulators. We shall then be able to count every day upon an average of from 600 to 800 watts-hour disposable for lighting.

This quantity of energy corresponds to 20 or 25 lamps-hour of 10 candles, reckoning the consumption of the incandescent lamps at the rate of three watts per candle—a figure at present easily reached. The best arrangement to adopt consists in making use of 16 accumulators in tension, supplying 30-volt lamps, the thermo-electric battery successively charging the first eight or the last eight elements of the battery previously divided into two groups. The thermo-electric stove with plates of tinned iron gives 35 volts in open circuit, and 3 amperes in short circuit, which corresponds to a maximum effective power of close to 44 watts.

In the presence of these encouraging results, Dr. Girand is studying out a stove of a larger size, which might serve both for lighting and heating small stores and railway stations, country seats, etc., and another model that might be arranged in kitchen ranges of the ordinary style; but these are as yet merely projects.

To return to things already realized, it remains for us to say a word about the consumption of fuel. Thermo-electric stoves consume no more or less fuel than other stoves of the same thermic power, for we have seen that the quantity of heat converted into electric energy is insignificant therein. In Dr. Giraud's apparatus, the consumption varies between 20 and 28 kilogrammes of coke per day. Reckoning a hectoliter of coke at 2 francs, and the maximum consumption at 28 kilogrammes per day, it will be seen that the cost of the fuel consumed is, at a maximum, one franc and a half a day.

As the stove produces sensibly 1 kilowatt-hour per day at this rate, it will be seen that the electric energy furnished costs exactly the same sum as that paid at present at central stations. Such cost is naturally increased by the interest and amortizement of the supplementary cost of the stove and of the coefficient of loss of the accumulators; but, as on another hand we have the heat to boot, it will be seen that the question presents itself in a very engaging way from an economical point of view.

The only point that experience has yet to decide is that of the preservation of the elements. A stove has been in operation for three months at Dr. Giraud's, and, up to the present, has not given the least sign of deterioration. Although such trial is not of sufficient duration to guarantee a lasting of the elements for a long time, it nevertheless constitutes a presumption that augurs well.

The thermo-electric stove, solving the problem of lighting during winter, leaves pending the question of lighting during summer. Little light is used during summer, and one has always other illuminants at his disposal, or he can even fire up the stove periodically in order to recharge the accumulators, care being taken to put the stove in a place where the heat offers no inconvenience.

Finally, there remains another solution, which is absolutely fanciful from an economical standpoint, but which is of a high scientific interest. This consists in charging the stove *with ice*, care being taken to change the direction of the communications with the accumulators, to reduce the number of them, and to provide for a flow of ice water. The stove will produce negative heat units, that is to say, it will cool a room. The greatest part of the heat thus absorbed will serve to melt the ice, and a small portion of it will be converted into electric energy, and will be stored up in the accumulators. As such energy will be ultimately converted into heat in the incandescent lamp, the thermo-electric stove, the accumulators and the lamp will have permitted, definitively, of that apparently paradoxical phenomenon of the production of high temperatures with ice.

Let us leave the domain of fancy to recognize, in closing, the fact that Dr. Giraud's stove presents a genuine interest and that it brings a new solution to the problem of domestic electric lighting in many cases where one has not a central distributing station to rely upon—*E. Hospitalier, in La Nature.*

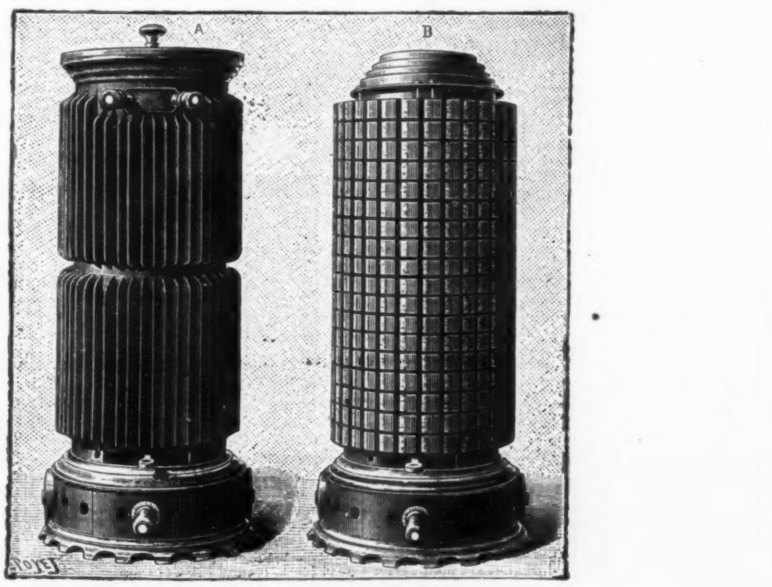


FIG. 1.—GIRAUD'S THERMO-ELECTRIC STOVE.

A. Model with ribbed jacket. B. Model with exposed elements.

PHOSPHORUS MAKING BY ELECTRICITY.

THE discovery that phosphorus could be extracted from the raw material by means of electricity was first made by Dr. Readmean, of Edinburgh, who took out a patent, and it is somewhat remarkable that a like conclusion with regard to the manufacture of this product was arrived at by Mr. T. Parker, the managing director to the Electrical Construction Corporation, and their chemist, Mr. A. E. Robinson, F.C.S.,

who conjointly had been experimenting on the subject for some months previously, and who also took out a patent about eighteen months ago. When it became known that two patents had been obtained, an arrangement was entered into, by which the whole of the information secured by the three inventors could be employed; and the success of the process having been demonstrated, the Electrical Construction Corporation decided to embark upon the manufacture of the article. Ground was secured at Wednesfield, plans of a suitable manufactory obtained, and so much of the building erected as would enable the firm to commence operations on a limited scale, so as to perfect the whole scheme of manufacture. At present, only a limited number of furnaces are in operation, but the machinery provided will be powerful enough to produce an electrical current capable of heating other furnaces when the premises are extended. The engine, a triple expansion of the marine type, is of 700 horse power, and supplied with the necessary energy from three of Babcock & Wilcox's latest improved boilers, fed with heated water, by which the cost of producing steam is reduced to a minimum. Attached to the engine is an alternating dynamo, nearly 8 feet in diameter, and when in full work able to produce 400 units of electricity. From the dynamo the current is conducted to the furnace and generates intense heat by means of powerful arc carbons. The furnace is the invention of Mr. Parker, it occupies comparatively a small amount of space, being only about 8 feet square and less in height, and is apparently constructed on very simple principles. It is fitted with a hopper at the top, which is so constructed that the phosphates and coke can be poured in without any heat or vapor escaping. The furnace being "air-tight," no smoke is generated, and the whole of the ingredients placed within, with the exception of a little slag which is drawn occasionally by a process of tapping, similar to that at ordinary blast furnaces, pass away in a vaporous condition through pipes and condensers, where the phosphorus is deposited in such a pure condition that it requires but little refining, though for marketable purposes it is afterward formed into circular cakes. So far as the process has been tested the cost of production is infinitely less than by any other system, and the method having now, after some months' trial, been thoroughly perfected, it is expected that the works will in a short time be enlarged. We understand that the whole of the patents have been acquired by the Phosphorus Company (Limited), by whom the works will in future be carried on. It may be interesting to state that the estimated consumption of phosphorus throughout the world is about two thousand tons per annum, and that it is hoped to be able at Wednesfield to place in the market at least half that quantity each year at a price which may probably have a marked effect upon the price of matches, low as they are retailed at the present day. The invention is another important instance of the development of electrical chemistry, which is, comparatively speaking, in its infancy, and it would be futile to speculate as to what uses it will be adapted in the future. Already it has been utilized in the manufacture of aluminum so successfully as to bring down the price from sovereigns to shillings a pound, and it has been brought into use in the production of copper, lead, and tin. Probably in a short time we may hear of electricity being introduced into other industries, as we understand that the inventors have taken out patents with this object. Doubtless manufacturers will watch the development of electrical appliances in connection with the production of metals and other wares with much interest.—*The Chem. Tr. Jour.*

ON ELECTRICAL EVAPORATION.*

By WILLIAM CROOKES, F.R.S.

IT is well known that when a vacuum tube is furnished with internal platinum electrodes, the adjacent glass, especially near the negative pole, speedily becomes blackened, owing to the deposition of metallic platinum. The passage of the induction current greatly stimulates the motion of the residual gaseous molecules; those condensed upon and in the immediate neighborhood of the negative pole are shot away at immense speed in almost straight lines, the speed varying with the degree of exhaustion and with the intensity of the induced current. Platinum being used for the negative pole, not only are the gaseous molecules shot away from the electrode, but the passage of the current so affects the normal molecular motions of the metal as to remove some of the molecules from the sphere of attraction of the mass, causing them to fly off with the stream of gaseous molecules proceeding from the negative pole, and to adhere to any object near it. This property was, I believe, first pointed out by Dr. Wright, of Yale College, and some interesting experiments are described by him in *The American Journal of Science and Arts.*† The process has been much used for the production of small mirrors for physical apparatus.

This electrical volatilization or evaporation is very similar to ordinary evaporation by the agency of heat. Cohesion in solids varies according to physical and chemical constitution; thus every kind of solid matter requires to be raised to a certain temperature before the molecules lose their fixity of position, and are rendered liquid, a result which is reached at widely different temperatures. If we consider a liquid at atmospheric pressure—say, for instance, a basin of water in an open room—at molecular distances, the boundary surface between the liquid and the superincumbent gas will not be a plane, but turbulent like a stormy ocean. The molecules at the surface of the liquid dart to and fro, rebound from their neighbors, and fly off in every direction. Their initial velocity may be either accelerated or retarded according to the direction of impact. The result of a collision may drive a molecule in such a direction that it remains part and parcel of the liquid; on the other hand, it may be sent upward without any diminution of speed, and it will then be carried beyond the range of attraction of neighboring molecules and fly off into and mingle with the superincumbent gas. If a molecule of the liquid has been driven at an angle with a velocity not sufficient to carry it beyond the range of the molecular attraction of the liquid, it may still escape, since, in its excursion upward, a gaseous molecule may strike it in the right direction, and its temporary visit may be converted into permanent residence.

The intrinsic velocity of the molecules is intensified by heat and diminished by cold. If, therefore, we raise the temperature of the water without materially increasing that of the surrounding air, the excursions of the molecules of the liquid are rendered longer and the force of impact greater, and thus the escape of molecules into the upper region of gas is increased, and we say that evaporation is augmented.

If the initial velocities of the liquid molecules can be increased by any other means than by raising the temperature, so that their escape into the gas is rendered more rapid, the result may be called "evaporation," just as well as if heat had been applied.

Hitherto I have spoken of a liquid evaporating into a gas; but the same reasoning applies equally to a solid body. But while a solid body like platinum requires an intense heat to enable its upper stratum of molecules to pass beyond the sphere of attraction of the neighboring molecules, experiment shows that a very moderate amount of negative electrification superadds sufficient energy to enable the upper stratum of metallic molecules to fly beyond the attractive power of the rest of the metal.

If a gaseous medium exists above the liquid or solid it prevents to some degree the molecules from flying off. Thus both ordinary and electrical evaporation are more rapid in a vacuum than at the ordinary atmospheric pressure.

I have recently made some experiments upon the evaporation of different substances under the electric stress.

Evaporation of Water.—A delicate balance was taken and two very shallow porcelain dishes were filled with acidulated water and balanced on the pans. Dipping into each dish—touching the liquid, but not the dish—was a platinum wire, one connected with the induction coil and the other insulated. The balance was left free to move, but was not swinging, the pointer resting at the center of the scale. The water in connection with the coil was first made positive. After 1¾ hours there was scarcely any difference between the weight of the insulated water and that which had been exposed to the positive current. Equilibrium being restored, the current was reversed, the negative current being kept on the dish for two hours. At the end of this time the electrified water was decidedly lighter. After having again restored equilibrium, the electrification of the dishes was reversed, *i. e.*, the one that had before been insulated was made negative and the other one was insulated. In an hour the electrified water had become decidedly lighter than the insulated water. The experiment was performed in a room of uniform temperature, and any draught was prevented by the glass case of the balance. In a subsequent experiment in which the quantities were weighed, it was found that negatively electrified water lost in 1½ hours $\frac{1}{1000}$ part of its weight more than did insulated water.

This experiment shows that the disturbing influence which assists evaporation is peculiar to the negative pole even at atmospheric pressures.

The metal cadmium was next experimented upon.

Evaporation of Cadmium.—If the flying off of the metal of the negative pole is similar to evaporation or volatilization, the operation should be accelerated by heat.

A tube was made as shown in Fig. 1. A and B are

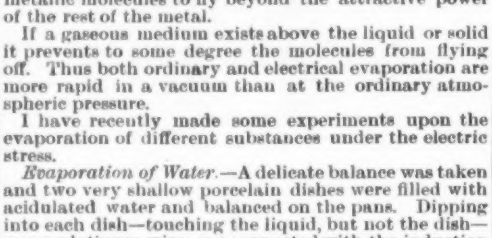


FIG. 1.

the platinum poles sealed through the glass. C and D are two blocks of metallic cadmium of the same size and weight. The piece, C, is in contact with the pole, B, which in the experiment was always kept negative, the pole, A, being positive. When the exhaustion was such that the passage of the current gave green phosphorescence over the glass, heat was applied simultaneously to both ends of the U-shaped tube by means of a gas burner and air bath, so that one piece of cadmium was at the same temperature as the other. The current was then applied and was kept on for about an hour, and it was remarkable that no metal was deposited in the neighborhood of the positive pole, the surrounding portion of the tube being quite clean, while the corresponding part of the other limb of the tube, having no electrodes, was thickly coated, the appearance being shown in the drawing.

As the temperature was high, metal had distilled off from both lumps; hence there was no visible difference in the amount of the deposit in the two sides. It is evident that to render the electrical action most visible, the temperature should be kept short of the normal volatilizing point.

In the next experiment an exactly similar tube was used; the vacuum was such that the green phosphorescence of the glass was well seen, the temperature was kept just below the melting point of cadmium, and the current was kept on for an hour. On examining the tube at the end of this time, the appearance was as seen in Fig. 2. A considerable deposit had taken place on the end of the tube near the negative pole, the space round the positive pole was clear, while in the limb of the tube where no electricity had been passing only a very little deposit of metal was seen, as shown in the figure.

The temperature in this experiment having been kept below the melting point, had no electricity been applied, there would have been very little, if any, evaporation. The amplitude of the molecular oscillations was increased by the rise of temperature, but not sufficiently to allow many of the molecules to pass beyond the sphere of attraction of the mass. When, however, the current was turned on, the oscillations were increased sufficiently to carry some of the molecules beyond their spheres of attraction and hence into the vacuous space above. As in the water experiment, this only happens at the negative pole. It would seem

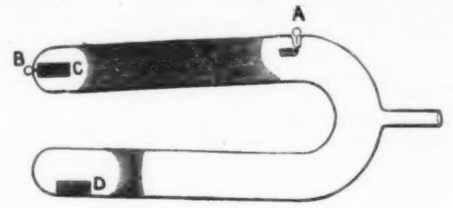


FIG. 2.

that, even after having been *removed* from the rest of the mass, the onrushing stream of gaseous molecules is necessary to carry the metallic molecules away, and, as I shall presently show, even then they very quickly drop out of the ranks and deposit on the walls of the tube.

Another tube was made as shown in Fig. 3. The

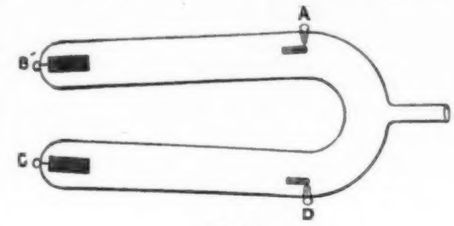


FIG. 3.

poles, A, B, C, D, were platinum wires sealed through the glass, A and D having aluminum poles covering the platinum wire. In the ends of the tube, and touching the poles, B and C, were two pieces of cadmium of the same size and shape. The tube was exhausted to the phosphorescent point, and the current was turned on, C being made negative and D positive. No heat was applied. The current was kept on for about half an hour, until a good deposit of metal had been deposited on the glass, the appearance being as shown in Fig. 4, the glass near the pole, C, being coated with

FIG 4.

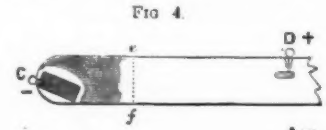


FIG. 5.

metal, while the glass round the pole, D, was clean. The outer boundary of the dark space during the experiment is shown by the dotted line, *e f*.

The pole, B, was now made positive and the pole, A, negative, the current being being kept on for another half hour. At the end of the time the only additional effect was a slight darkening round the lump of cadmium, in the same place as, but very much fainter than, the deposit shown in Fig. 5. This is probably due to a little leakage of negative discharge from the positive pole. The experiment shows that positive electrification does not cause the metal sensibly to volatilize.

In these experiments no estimation was made of the weight of metal removed, and the cadmium only rested by its own weight upon the platinum wires that had been sealed through the glass. To render the experiment quantitative, and at the same time to remove any disturbing effect that might be caused by heating at the point of indifferent contact, the following experiments were made:

A U-shaped tube, shown in Fig. 6, had a platinum

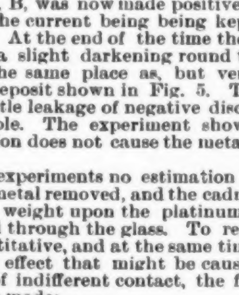


FIG. 6.

pole sealed in each end; 6 grains of pure cadmium were put into each limb and fused round the platinum wire. The ends of the tube were then put into an air bath, and kept at a temperature of 200° C. during the continuance of the experiment.* The exhaustion remained at 0·00076 mm., or 1 M. The induction current was kept going for 35 minutes, the pole A being negative and B positive. At the end of this time it was seen that most of the cadmium had disappeared from the negative pole, leaving the platinum wire clean, no

* A paper lately read before the Royal Society.

† Third Series, vol. 13, p. 49, January, 1877, and vol. 14, p. 169, September, 1877.

* Cadmium melts at 320 deg. and boils at 860 deg.

metal being deposited near it, and the molecules appearing to have been shot off to a distance of about ¾ inch. The appearance of the positive pole was very different; scarcely any of the cadmium had been volatilized, and the condensed metal came almost close to the pole. The tube was opened, and the remaining wires and metal were weighed. The cadmium was then dissolved off the poles in dilute acid; the residue was washed, dried, and weighed.

	Positive pole.	Negative pole.
	grs.	grs.
Original weight of cadmium	6·00	6·00
Cadmium remaining on the pole	3·65	0·25
Cadmium volatilized in 35 minutes	2·35	5·75

The difference between the amount of cadmium driven from the two poles having proved to be so decided, another experiment was tried in a tube so arranged that the metal could be more easily weighed before and after the experiment. The apparatus is shown in Fig. 7. A tube was blown U-shaped, having

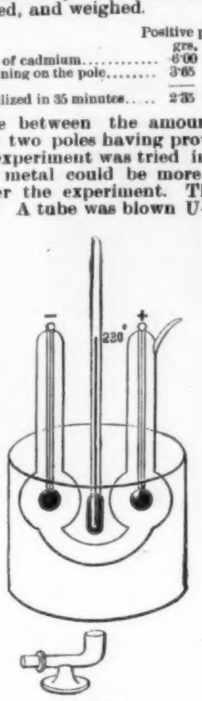


FIG. 7

a bulb in each limb. The platinum poles were as before at the extremities of each limb, and in each bulb was suspended from a small platinum hook a small lump of cadmium, the metal having been cast on to the wire. The wires were each weighed with and without the cadmium. The tube was exhausted, and the lower half of the tube was inclosed in a metal pot containing paraffin wax, the temperature being kept at 230° C. during the continuance of the experiment. A deposit around the negative pole took place almost immediately, and in five minutes the bulb surrounding it was opaque with deposited metal. The positive pole with its surrounding luminosity could be easily seen the whole time. In 30 minutes the experiment was stopped, and after all was cold the tube was opened and the wires weighed again. The results were as follows:

	Positive pole.	Negative pole.
	grs.	grs.
Original weight of cadmium	9·34	9·38
Weight after experiment	9·25	1·86
Cadmium volatilized in 30 minutes	0·09	7·52

Finding that cadmium volatilized so readily under the action of the induction current, a large quantity, about 350 grs. of the pure metal, was sealed up in a tube arranged as in Fig. 8, and the end of the tube containing

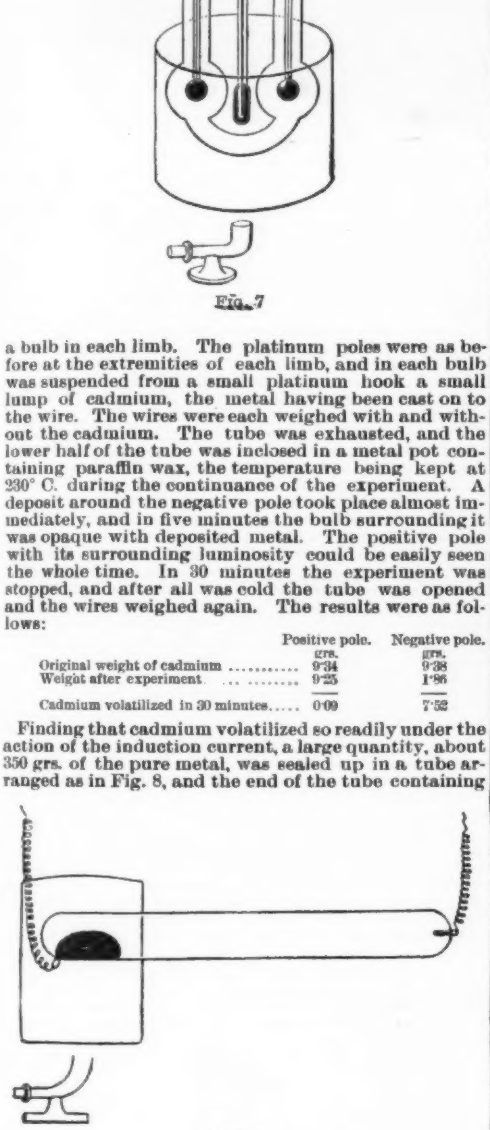


FIG. 8

the metal was heated to a little above the melting point; the molten metal being made the negative pole, in a few hours the whole quantity had volatilized and condensed in a thick layer on the far end of the tube, near, but not touching, the positive pole.

Volatilization of Silver.—Silver was the next metal experimented upon. The apparatus was similar to that used for the cadmium experiments, Fig. 7. Small lumps of pure silver were cast on the ends of platinum wires, and suspended to the inner ends of platinum terminals passing through the glass bulb. The platinum wires were protected by glass, so that only the silver balls were exposed. The whole apparatus was inclosed in a metal box lined with mica, and the temperature was kept as high as the glass would allow without softening. The apparatus was exhausted to a dark space of 3 mm., and the current was kept on for 1½ hours. The weights of silver, before and after the experiment, were as follows:

	Positive pole.	Negative pole.
Original weight of silver	18·14 grains.	24·63 grains.
Weight after the experiment	18·13 "	24·44 "
Silver volatilized in 1½ hours	0·01 "	0·19 "

It having been found that silver volatilized readily from the negative pole in a good vacuum, experiments were instituted to ascertain whether the molecules of metal shot off from the pole were instrumental in producing phosphorescence. A glass apparatus was made, as shown in Fig. 9. A pear-shaped bulb of German glass has, near the small end, an inner concave negative pole, A, of pure silver, so mounted that its inverted image is thrown upon the opposite end of the tube. In front of the pole is a screen of mica, having a small hole in the center, so that only a narrow pencil of rays from the silver pole can pass through, forming a bright spot of phosphorescence, D, at the far end of the bulb. The exhaustion was pushed to a high point, 0·00068 mm., or 0·9 M. The current from an induction

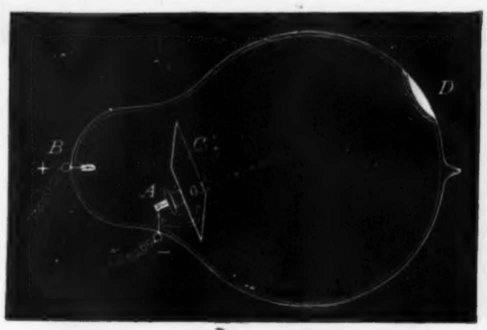


FIG. 9.

P = 0·00068 mm.
= 0·9 M.

coil was allowed to pass continuously for some hours, the silver pole being kept negative so as to drive off a certain portion of the silver electrode. On subsequent examination it was found that the silver had all been deposited in the immediate neighborhood of the pole, while at the far end of the tube the spot, D, that had been continuously glowing with phosphorescent light, was practically free from silver.

A tube was next made as shown in Fig. 10. It had two negative poles connected together, AA', so placed as to project two luminous spots on the phosphorescent glass of the tube. One of the electrodes, A', was of silver, a volatile metal; the other, A, was of aluminum, practically non-volatile. On connecting the two negative poles, AA', with one terminal of the coil, and the positive pole, B, with the other terminal,

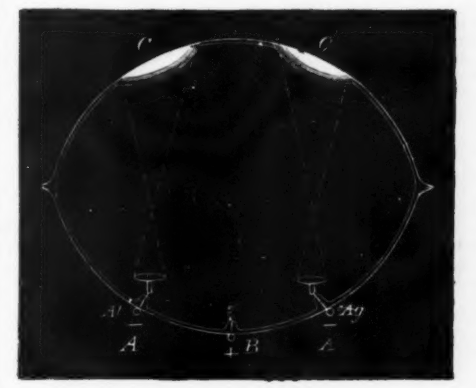


FIG. 10.

P = 0·00068 mm.
= 0·9 M.

it was seen in the course of half an hour that a considerable quantity of metal had been projected from the silver negative pole, blackening the tube in its neighborhood, while no projection of metallic particles took place from the aluminum positive pole. During the whole time of the experiment, however, the two patches of phosphorescent light, C and C', had been glowing with exactly the same intensity, showing that the active agent in effecting phosphorescence was not the molecules of the solid projected from the poles, but the residual gaseous particles, or "radiant matter."

In the tubes hitherto made containing silver, it had not been easy to observe the spectrum of the negative pole, owing to the rapid manner in which the deposit obscured the glass. A special tube, Fig. 11, was therefore devised of the following character. The silver pole, A, was attached to the platinum pole at one end of the tube, and the aluminum positive pole, B, was at the side. The end of the tube opposite the silver pole was rounded, and the spectroscope was arranged to observe the light of the volatilizing silver "end on," as shown in the figure. In this way the deposit of silver offered no obstruction to the light, as none was deposited except on the sides of the tube surrounding the silver. At a vacuum giving a dark space of about 3 mm. from the silver, a greenish white glow was seen to surround the metal. This glow gave a very brilliant spectrum. The spark from silver poles in air was brought into the same field of view as the vacuum glow, by means of a right-angled prism attached to the spectroscope, and the two spectra were compared. The two strong green lines of silver were visible in each spectrum; the measurements taken of their wave lengths were 3,344 and 3,675, numbers which are so close to Thalen's numbers as to leave no doubt that

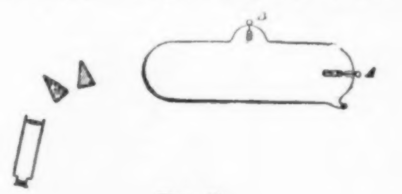


FIG. 11.

they are the silver lines. At a pressure giving a dark space of 2 mm. the spectrum was very bright, and consisted chiefly of the two green lines and the red and green hydrogen lines. The intercalation of a Leyden jar into the circuit does not materially increase the brilliancy of the lines, but it brings out the well known air lines. At this pressure not much silver flies off from the pole. At a higher vacuum, the luminosity round the silver pole gets less and the green lines vanish. At an exhaustion of about one-millionth of an atmosphere the luminosity is feeble, the silver pole has exactly the appearance of being red hot, and the volatilization of the metal proceeds rapidly.*

If, for the negative electrode, instead of a pure metal such as cadmium or silver, an alloy was used, the different components might be shot off to different distances, and in this way make an electric separation, a sort of fractional distillation. A negative terminal was formed of clean brass, and submitted to the electrical discharge *in vacuo*; the deposit obtained was of the color of brass throughout, and on treating the deposit chemically I could detect no separation of its component metals, copper and zinc.

Returning to the analogy of liquid evaporation, if we take several liquids of different boiling points, put them under the same pressure, and apply the same amount of heat to each, the quantity passing from the liquid to the gaseous state will differ widely in each case.

It was interesting to try a parallel experiment with metals, to find their comparative volatility under the same conditions of temperature, pressure and electrical influence. It was necessary to fix upon one metal as a standard of comparison, and for this purpose I selected gold, its electrical volatility being great, and it being easy to prepare in a pure state.

An apparatus was made as in Fig. 12. It is practi-

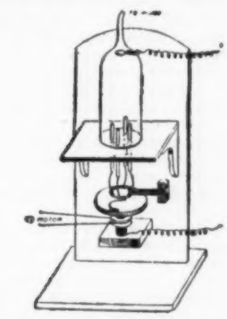


FIG. 12

cally a vacuum tube with four negative poles at one end and one positive pole at the other. By a revolving commutator I was able to make electrical connection with each of the four negative poles in succession for exactly the same length of time (about six seconds); by this means the variations in the strength of the current, the experiment lasting some hours, affected each metal alike.

The exposed surface of the various metals used as negative poles was kept uniform by taking them in the form of wires that had all been drawn through the same standard hole in the draw plate, and cutting them by gauge to a uniform length. The actual size used was 0·8 mm. in diameter, and 20 mm. long.

The comparison metal gold had to be used in each experiment. The apparatus thus enabled me to compare three different metals each time. The length of time that the current was kept on the revolving commutator in each experiment was eight hours, making two hours of electrification for each of the four negative electrodes. The pressure was such as to give a dark space of six mm.

The fusible metals—tin, cadmium, and lead—when put into the apparatus in the form of wires, very quickly melted. To avoid this difficulty a special form of pole was devised. Some small circular porcelain basins were made, 9 mm. diameter; through a small hole in the bottom a short length of iron wire, 0·8 mm. in diameter, was passed, projecting downward about 5 mm.; the basin was then filled to the brim with the metal to be tested, and was fitted into the apparatus exactly in the same way as the wires; the internal diameter of the basins at the brim was 7 mm., and the negative metal filed flat was thus formed of a circular disk 7 mm. diameter. The standard gold pole being treated in the same way, the numbers obtained for the fusible metals can be compared with gold, and take their place in the table.

The following table of the comparative volatilities was in this way obtained, taking gold as = 100:

Palladium	108·00	Platinum	44·00
Gold	100·00	Copper	40·24
Silver	82·68	Cadmium	31·99
Lead	75·04	Nickel	10·99
Tin	56·96	Iridium	10·49
Brass	51·58	Iron	5·50

In this experiment equal surfaces of each metal were exposed to the current. By dividing the numbers so obtained by the specific gravity of the metal, the following order is found:

Palladium	9·00	Copper	2·52
Silver	7·88	Platinum	2·02
Tin	7·76	Nickel	1·29
Lead	6·61	Iron	0·71
Gold	5·18	Iridium	0·47
Cadmium	3·72		

* Like the action producing volatilization, the "red heat" is confined to the superficial layers of molecules only. The metal instantly assumes, or loses, the appearance of red heat the moment the current is turned on or off, showing that, if the appearance is really due to a rise of temperature, it does not penetrate much below the surface. The extra activity of the metallic molecules necessary to volatilize them is, in these experiments, confined to the surface only, or the whole mass would evaporate at once, as when a metallic wire is deflagrated by the discharge of a powerful Leyden jar. When this extra activity is produced by artificial heat one of the effects is the emission of red light; so it is not unreasonable to imagine that when the extra activity is produced by electricity the emission of red light should also accompany the separation of molecules from the mass. In comparison with electricity heat is a wasteful agent for promoting volatilization, as the whole mass must be raised to the requisite temperature to produce a surface action merely; whereas the action of electrification does not appear to penetrate much below the surface.

Aluminum and magnesium appear to be practically non-volatile under these circumstances.

The order of metals in the table shows at once that the electrical volatility in the solid state does not correspond with the order of melting points, of atomic weights, or of any other well-known constant. The experiment with some of the typical metals was repeated, and the numbers obtained did not vary materially from those given above, showing that the order is not likely to be far wrong.

It will be seen in the above table that the electrical volatility of silver is high, while that of cadmium is low. In the two earlier experiments, where cadmium and silver were taken, the cadmium negative electrode in 30 minutes lost 7·52 grains, while the silver negative electrode in 1½ hours only lost 0·19 grain. This apparent discrepancy is easily explained by the fact (already noted in the case of cadmium) that the maximum evaporation effect, due to electrical disturbance, takes place when the metal is at or near the point of liquefaction. If it were possible to form a negative pole *in vacuo* of molten silver, then the quantity volatilized in a given time would be probably much more than that of cadmium.

Gold having proved to be readily volatile under the electric current, an experiment was tried with a view to producing a larger quantity of the volatilized metal. A tube was made having at one end a negative pole composed of a weighed brush of fine wires of pure gold, and an aluminum pole at the other end.

The tube was exhausted and the current from the induction coil put on, making the gold brush negative; the resistance of the tube was found to increase considerably as the walls became coated with metal, so much so that, to enable the current to pass through, air had to be let in after a while, depressing the gauge ½ mm.

The weight of the brush before experiment was 35·4940 grains. The induction current was kept on the tube for 14½ hours; at the end of this time the tube was opened and the brush removed. It now weighed 32·5613, showing a loss of 2·9327 grains. When heated below redness, the deposited film of gold was easily removed from the walls of the tube in the form of very brilliant foil.

After having been subjected to electrical volatilization, the appearance of the residual piece of gold under the microscope, using a ¼ in. object glass, was very like that of electrolytically deposited metal, pitted all over with minute hollows.

This experiment on the volatilization of gold having produced good coherent films of that metal, a similar experiment was tried, using a brush of platinum as a negative electrode. On referring to the table it will be seen that the electrical volatility of platinum is much lower than that of gold, but it was thought that by taking longer time a sufficient quantity might be volatilized to enable it to be removed from the tube.

The vacuum tube was exhausted to such a point as to give a dark space of 6 mm., and it was found, as in the case of gold, that as a coating of metal was deposited upon the glass the resistance rapidly increased, but in a much more marked degree, the residual gas in the tube apparently becoming absorbed as the deposition proceeded. It was necessary to let a little air into the tube about every 30 minutes, to reduce the vacuum. This appears to show that the platinum was being deposited in a porous, spongy form, with great power of occluding the residual gas.

Heating the tube when it had become in this way non-conducting liberated sufficient gas to depress the gauge of the pump 1 mm., and to reduce the vacuum so as to give a dark space of about 3 mm. This gas was not reabsorbed on cooling, but on passing the current for 10 minutes the tube again refused to conduct, owing to absorption. The tube was again heated, with another liberation of gas, but much less than before, and this time the whole was reabsorbed on cooling.

The current was kept on this tube for 25 hours; it was then opened, but I could not remove the deposited metal except in small pieces, as it was brittle and porous. Weighing the brush that had formed the negative pole gave the following results:

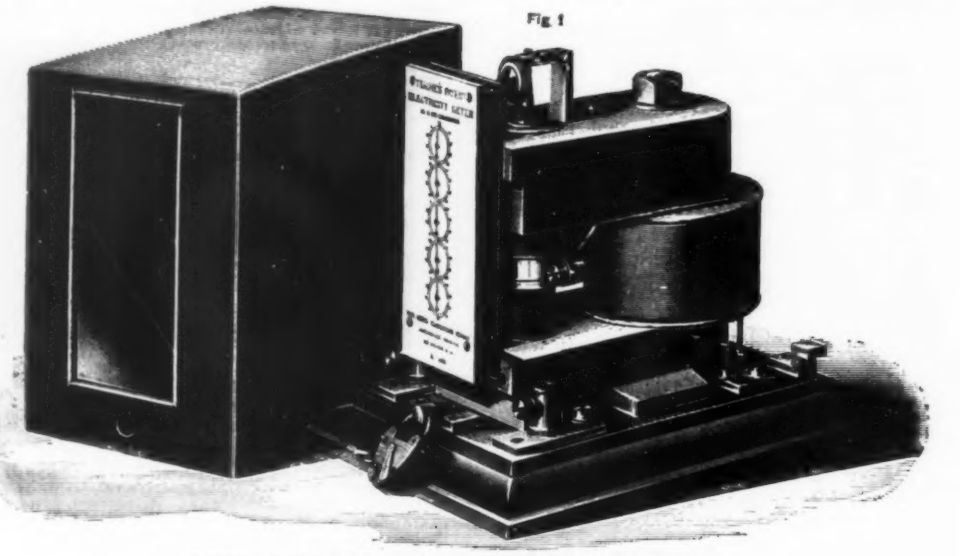
	Grains.
Weight of platinum before experiment.	10·1940
" " after experiment..	8·1570
Loss by volatilization in 25 hours......	2·0370

Another experiment was made similar to that with gold and platinum, but using silver as the negative pole, the pure metal being formed into a brush of fine wires. Less gas was occluded during the progress of this experiment than in the case of platinum. The silver behaved the same as gold, the metal deposited freely, and the vacuum was easily kept at a dark space of 6 mm. by the very occasional admission of a trace of air. In 20 hours nearly three grains of silver were volatilized. The deposit of silver was detached without difficulty from the glass in the form of brilliant foil.

THE TEAGUE ELECTRICITY METER.

The Teague electricity meter has recently been brought out by the Acme Electric Works, London, of which Mr. Francis Teague is manager. We now illustrate the instrument in the accompanying cuts. Fig. 1 is a view of the instrument with the cover removed, and Fig. 2 a section. It consists of an electro-motor of the simplest form, the armature consisting of a hollow cylinder of copper, aluminum, or other non-magnetic metal, which is placed in an intense magnetic field, which is formed by boring a hole in the end of one pole piece of a magnet, and allowing the opposite pole piece to extend through this hole. It is, however, made somewhat smaller than the hole in diameter, leaving a space for the armature to revolve in. The current is led to and from the armature by means of two mercury contact troughs, one of which is connected to the spindle and the other to the lower edge of the armature, and the whole so arranged that practically no air can reach the surface of the mercury. The armature is geared direct to the train of wheels which carry the pointers, and the result is read off in absolute Board of Trade units without the use of constants or multipliers, thus rendering it possible for a consumer to check the record as easily as with an ordinary gas meter. The total energy absorbed in each meter is five watts, and this loss is the same in all the different types. The range is from 0·5 to 10 amperes for the smaller sizes made, and the larger sizes begin to register at proportionally low currents. The calibration is very simply effected, and by varying the immersion of the lower edge of the armature cylinder the standard speed per

Fig 1



THE TEAGUE ELECTRICITY METER.

ampere is easily obtained. The capacity of any type of meter depends upon the thickness of the armature cylinder, and the sectional area of the wire forming the compensating coil, which consists of one layer only, wound in series round the magnet cores. The greatest strength of field is obtained with a very high resistance shunt winding. The armature spindle is accurately balanced, and is mounted upon jeweled bearings, and provision is made for relieving the bottom step jewel of the weight of the armature and spindle. The whole of the meter is inclosed in a dust-proof case, as shown in our illustration, and this can be locked up or sealed so as to prevent it from being tampered with. The magnetic field is, we are informed, unaffected by the presence of magnetic bodies in the neighborhood.

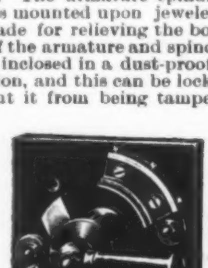
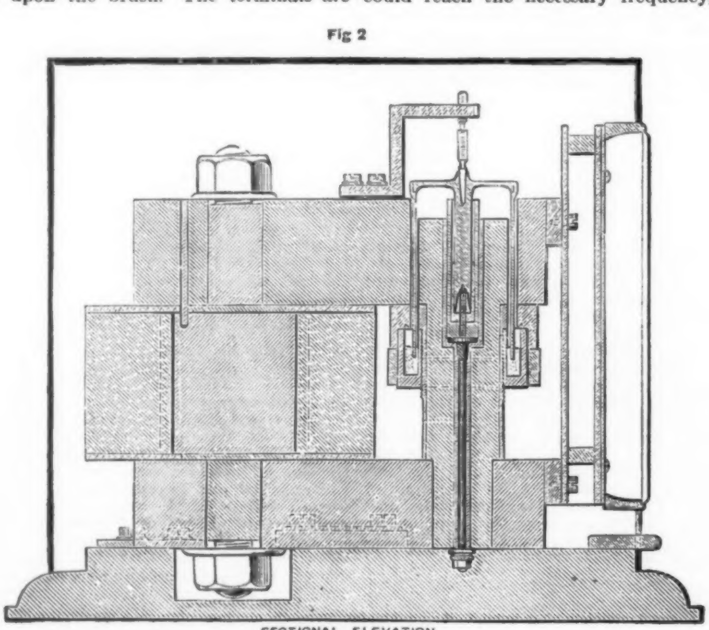


Fig. 3.

The same firm also exhibited the Cockburn patent quick-break lock switches. The amount of spring necessary to insure the ends of the contact brush bedding properly upon the terminal plates is obtained by the flexibility of the brush itself, which is made of thin rolled copper, in this point resembling those made by Messrs. Crompton and others. A special feature of the switch, however, is the construction of the terminal plates, which are segments of a circle, and are adjustable by means of screws, so as to compensate for considerable wear upon the brush. The terminals are mounted upon enameled slate bases, and the ends of the brush are turned to a corresponding curve, as shown in the illustration. These switches are also made coupled for double pole work, and are made to carry from 15 to 1000 amperes and upward.—*The Engineer.*

Fig 2



SECTIONAL ELEVATION

TESLA'S EXPERIMENTS WITH ALTERNATING CURRENTS OF HIGH FREQUENCY.

The Wednesday evening session of the American Institute of Electrical Engineers was held in Prof. Dwight's room, Columbia College, and will long be remembered by those present, not only on account of the brilliant experiments shown, but also for the many possibilities which it suggested in the development of the artificial illumination of the future. For the purpose of his experiments, Mr. Tesla employed the alternating machine with 384 poles, described in the *Electrical Engineer* of March 18, 1891, which, when run at full speed, permitted him to obtain 20,000 alternations per second. The currents of this machine in all of Mr. Tesla's experiments were first run through a condenser in order to avoid the possibility of injury to the machine. The machine itself was set up in the electrical workshop of the college, and was driven by an electric motor, the speed of which could be varied by a switch on the lecture platform.

Mr. Tesla introduced his subject by the remark that modern science has been able to make rapid strides by the recognition of ether as the medium of transmission of vibrations of various forms which manifest themselves to our senses. We are therefore now able to see things in a different light than was formerly the case, and, being tolerably well able to explain them, the truth cannot be hidden much longer. The answer to the question, "What is electricity?" we were not yet prepared to give. We were justified in assuming, however, that electric phenomena are ether phenomena, and we may consider the phenomena of static electricity as phenomena of ether under strain, and those of dynamic electricity and electro magnetism as phenomena of ether in motion.

Mr. Tesla, while expressing the highest consideration for the work of Dr. Lodge, was not in entire accord with the views advanced by him, which he considered to be more of the nature of ingenious explanations than of a probable theory, Mr. Tesla contending that there can be no two electricities.

Alluding further to the electro magnetic theory of light, and to the Hertz experiments and those of Dr. Lodge and their application to the production of an efficient source of light, Mr. Tesla considered the electro magnetic waves as unavailable for the production of luminous effects, for the reason that long before we could reach the necessary frequency, the conductor would become opaque to the passage of the waves. Mr. Tesla thought that electro magnetic waves, unless they have the frequency of true light waves, cannot produce luminous effects. Not so, however, with the electrostatic waves or thrusts. These, no matter what their frequency, can excite luminous radiation. He

reasoned that the static effects in the Hertz and Lodge experiments were excessively small, due to the fact that they were produced in a practically closed coil, the spark acting as a bridge, making the coil practically continuous and depressing the potential. To obtain the desired difference of potential we must work with an open circuit generator of high potential of high frequency to enhance the electrostatic effects, and it was the recognition of this fact which led Mr. Tesla to the results he showed.

In carrying out this idea of obtaining enormous differences of potential, Mr. Tesla at once encountered the difficulty of obtaining the requisite insulation for the induction coil employed by him. His experience demonstrated that what we consider the best insulators, such as glass and rubber, are inferior to others, not formerly so considered, such as oil and wax. Mr. Tesla then started a spark coil in action, the primary of which was in connection with his alternator, which was speeded to give from 10,000 to 11,000 alternations per second. The coil emitted a clear note, which rose as the number of alternations was increased. As the discharges took place between the terminals of the coil, an exhausted Geissler tube held in proximity to the discharge did not light, but upon blowing out the arc the tube lighted up, which was due to the rise of potential caused by the rupture of the arc. This effect Mr. Tesla considered as purely electrostatic.

Mr. Tesla then showed the influence of insulated bodies having considerable size upon the spark length, demonstrating the effect of capacity upon the nature of the discharge. Thus when we attach an insulated body to the terminal of the coil, the potential may be raised or lowered. He showed this by wrapping an insulated wire of about one foot in length about one terminal of the coil and touching the other terminal with a brass sphere held in the hand; under these conditions streams of light emanated from all sides of the wire. When the sphere was removed, however, the streams disappeared almost entirely. He then cut off the wire in successive lengths, and the stream discharges became more marked and brilliant. He then attached a fine platinum wire to the terminal, which also showed the streams to a remarkable degree, and kept up a continuous vibration to and fro. He also showed a pinwheel effect, the wheel being rapidly rotated, with streams issuing from the two points. Another experiment consisted in attaching two spheres of about four inches diameter to the terminals. The spark passes first between the two points nearest to each other on the spheres, then works up toward their tops, is extinguished and re-established at the first point, this being continuously repeated. The neighboring exhausted tubes and lamps were illuminated and extinguished in unison with the action of the spark between the spheres.

These Mr. Tesla pointed out were not electro magnetic vibrations like the Hertz waves. He showed how by the use of the dielectric the spark is induced to jump between the separated spheres, due to the increase in the specific inductive capacity of the medium, and he also demonstrated that the streaming discharge passed easily through thick glass plates, rubber plates, and a book. Mr. Tesla then showed these static effects in a non-striking vacuum. A tube of this nature when connected to the machine glowed brightly, and the terminals became incandescent. Mr. Tesla then remarked that if, instead of using a filament in a lamp—which necessarily limited us in the degree of incandescence which we could practically employ—we could employ solid blocks of carbon, much higher efficiency could be obtained. Based upon this reasoning, he had constructed a lamp which he showed, containing two blocks of carbon in a non-striking vacuum. When connecting these two carbons to the two terminals of the coil, or one to one terminal and the other to a body of some size, the blocks can be raised to high incandescence.

Mr. Tesla also showed a lamp with but a single rod filament in a non-striking vacuum with no outward connection. The energy is entirely transferred by condenser action through the medium of condenser coatings in the base of the lamp. He also pointed out how the brilliancy of the lamp could be varied by simply altering the relative positions of the condenser coatings. This Mr. Tesla followed by demonstration of the phenomena with an unexhausted globe, and a single filament mounted therein. The filament when connected to one terminal of the coil heats up to bright incandescence and spins around in the globe. He also demonstrated the heating by the use of Crookes' well known apparatus consisting of mica vanes mounted above a platinum wire, which was brought to incandescence by connection with one terminal of the coil, and rotated the mica vanes.

In order to still further verify the conclusions that the electrostatic effects are alone active, Mr. Tesla placed a Geissler tube at right angles to the coil and at its center. In this position the tube did not light up. When placed at the ends, however, the tube lit up brilliantly and gave sufficient light to read by. Mr. Tesla showed both uranium and yttria tubes.

He then showed how exhausted tubes could be made to glow in an electrostatic field. For this purpose two large sheets of zinc were connected to the terminals of the machine at a distance of about 15 feet apart. The tube when placed between these sheets glowed brilliantly and could be moved about freely. Mr. Tesla remarked that, by merely creating such a field in a room, the mere suspension of the tubes in the room would afford the desired illumination.

Coming to the physiological effects, Mr. Tesla adjusted the conditions so that by touching one terminal with a brass sphere he raised the potential of the coil so enormously that a stream of light came out on the other terminal, and he estimated the difference of potential to be nearly 250,000 volts, and then performed the remarkable experiment of receiving the total discharge through his body, protecting his hands from burning by the brass balls held in his hands.

He then lit up lamps by holding them in contact with one terminal or near to the coil.

The lecturer then came to another class of experiments. He stated that he had used a system of conversion from high tension to low with the enormous frequencies of the condenser discharges. Mr. Tesla then showed an interesting experiment, which consisted in passing the converted currents, produced in the manner just described, through a copper bar 3/8 inch in diameter and bent into a loop. Ordinarily such a bar would constitute a short circuit, but Mr. Tesla succeeded in bringing lamps stretched across the parallel sides of the bar to incandescence, demonstrating that the impedance in the loop connecting the two sides was so great as to practically prevent the current from passing through it, and hence acting upon the lamps in the manner described. He also pointed out the existence of modes on the bar. His method consists in continuously charging and disruptively discharging a condenser into the working circuit, the charging of the condenser being effected by a coil operated either by alternating or direct currents. By this means any desired higher frequency may be obtained from any lower frequency.

Mr. Tesla concluded his experiments by exhibiting in action a simple alternate current arc lamp, operated by currents direct from the machine, giving 20,000 alternations per second. The light was beautifully steady and the arc entirely free from the hum accompanying arcs operated with currents of low frequency.

We have given but the merest outline of the many beautiful and highly suggestive experiments made by Mr. Tesla. Notwithstanding the fact that Mr. Tesla excited the intensest interest of his audience for three hours, he was nevertheless unable, for lack of time, to bring before them many experiments, some of which, he said, were even of a more striking nature than those brought out.—*Electrical Engineer.*

NOTES ON PERSPECTIVE DRAWING AND VISION.

By Dr. P. H. EMERSON and T. F. GOODALL.

SOME years ago we made some experiments with the object of comparing a monocular perspective drawing with the drawing of an aplanatic photographic lens. We found that under similar conditions they were alike, as was, of course, *a priori*, probable. More than a year ago one of us published a short paper, with an experiment, which threw grave doubts upon the truth of perspective drawing when compared with what the eye really sees.

We now offer a series of provisional propositions, experiments, proofs and deductions, which we venture to think are of fundamental importance to all artists, as well as to physiologists and psychologists. We are working now to still further elucidate the matter, but we decided to publish the following notes, so that specialists might perhaps help us in the matter.

Our experiments and deductions, if correct, will show that for scientific reasons the accepted rules of monocular perspective are likely to mislead the artist, and prove the fallacy of photographic and all mechanical methods of measurement.

Proposition A. —The eye does not constitute a symmetrical lens,* the top and bottom portions being different. That portion of the eye which perceives distance and distant objects (*i. e.*, those above the ground) sees the objects on a larger scale than the portion of the eye which views the foreground or nearer objects. Therefore our impression of nature is not what we get with a mathematically correct perspective drawing, or the drawing of an aplanatic photographic lens. That is, a perspective drawing surprises us by making the foreground objects look larger in proportion to the distance. Also we see a larger arc with the lower half of the eye than with the upper.

Proof 1.—That we do not see the same amount with both halves of the eye (upper and lower) is proved by the observer lying on his back and looking straight up at the sky, when he will find that the field of vision of the upper half is much more limited than the space seen by the lower half of the eye. This holds for either one eye alone or for both when used together.

The proof is completed when we stand with our legs apart, and standing with our back to the landscape, bend down and look between our legs. Here the fields are inverted, and consequently the distance appears small and far off, and gives much more the appearance of a sharp photographic rendering of the scene. This peculiar effect has long been well known and it has puzzled a good many observers, but hitherto no valid scientific explanation has been offered.

Proposition B.—We think this may be the result of the naturally selective action of the retinal nerves. It has been to our advantage in the struggle for life to see all the objects near to us and close around clearly, and to compass as wide a field as possible. It has also been to our advantage in the struggle for life for certain parts of nerves to try and draw distant objects nearer and to enlarge them, so that special functions may have developed purely by natural selection.

Deduction 1.—That mathematical perspective drawing gives quite a false impression of what we see when using *either one of our eyes or both.*

That such is actually the case we will now endeavor to prove, at the same time still further supporting our contention that the upper and lower portions of the eye see objects in different perspectives.

Proof 1.—Let the observer select a church tower or tall chimney for experiment. If the sides are parallel the object will *appear* to his eye wider at the top than at the bottom when he stands facing it at the distance of the tower itself and looks steadily at its center. These experiments are best made in the diffused light of evening. The experimenter must not move his eyes up and down the tower from top to bottom, and so *measure or correct* his impressions, but he must look steadily at the center of the tower and take his pure sensuous impressions. As most towers and chimneys do taper considerably, the result the observer gets when close to them is that they *look parallel* or nearly so. This fact was, no doubt, felt by the architects of the Parthenon, and it has never been known why they built the columns leaning inward, a little out of the perpendicular. That they were built out of plumb has been proved by measurement, that they *look* parallel is well known, and the reason of this we venture to find in our proposition.

Proof 2.—A very simple proof is to look about the middle of a doorway or door ; it will be felt that the door or doorway is wider at the top than the bottom. The same holds with books in a book-case.

Proof 3.—Cut two slips of paper—

(*a*) 8 inches long by 2 inches wide.
(*b*) 8 inches long by 2 inches by 1 7/8 inches wide, so that it tapers 1/8 of an inch.

If the parallel slip (*a*) be held upright 8 inches from the eye (its own length) and looked at straight in the center—the center of the paper being opposite to the eye—the paper will appear slightly wider at the top than at the bottom, the same proviso of not correcting the pure impression by measurement (looking up and down it) holding, as we pointed out in the case of the church tower.

If the observer now takes the tapering slip, *b*, and holds it narrow end upward, looking at it in the same way, it will *appear* parallel; if he holds it wide end upward, it will appear much wider at the top than at the bottom.

This holds equally true if the experiments are made either with one eye or both—showing that binocular vision has no effect on the impressions.

Proof 4.—Another interesting experiment is to place a penny upright on a table and a halfpenny 18 in. behind it and a little to the right or left of the penny. The eye must look *over* the penny at the halfpenny, so that the penny is a foreground object and the half penny a distant object. If the observer now looks steadily at the halfpenny, at the same time seeing the penny, he will find the impression given is that the halfpenny looks nearly as large as the penny.

Proposition A and proofs deal mainly with what we would describe as *vertical vision*—that is, with the variations in the appearances of objects when placed one over the other, as in a vertical column, or with objects at a distance as compared with objects in the foreground.

But within the radius where binocular vision acts (calculated by Mr. T. R. Dallmeyer to be 60 yards) new and important variations occur. These properties we shall consider under the term of horizontal vision.

Proposition.—Within the limits where binocular vision is effective (say normal vision—8 inches—to 60 yards) objects *appear smaller when they are compared with objects beyond the binocular limit*—that is, they appear smaller as compared with drawings as given by monocular or mathematical perspective.

An experiment to practically bring the effect of the binocular vision variations entering into the matter may be made as follows :

Take the tapering slip of paper aforesaid, *b*, and place it between the two eyes, the wide end resting upon the bridge of the nose, the slip being inclined at an angle of 30° with the horizon. The result is that the paper vanishes *toward* the eyes—diametrically an opposite result to what perspective would lead us to expect. This phenomenon still holds if the paper be gradually moved away from the eyes and held at arm's length, but in the same plane.

Proof.—Place a book at a distance of 6 ft. from the eyes. Then proceed to measure the width of the book with a pencil (one eye being closed), as a draughtsman draws objects by monocular perspective, and then open the other eye and measure the width of the book with both eyes. The binocular measurement will be found to be smaller than the monocular measurement. If the height of the book be measured in the same way, there will be no difference in the result obtained with one or both eyes.

But more convincing is Proof 2. Wafer a square sheet of white paper (say eight inches square) on the wall or on a window six feet from the observer, and look at it. The impression given will be that it is larger vertically than it is horizontally. This explains the old trick of marking off the height of a tall hat against a wall ; as a rule everybody places the mark too high—the reason is now explained.

Still another proof. Stand a halfpenny and penny on the table, as directed in the previous experiment. Now place the eyes on the same level as the plane of the table and observe. The result will be exactly the reverse to that previously obtained. That is when looking directly at the halfpenny, at the same time looking (indirectly) at the penny, the penny will appear the larger, and *vice versa*, when looking directly at the penny and indirectly at the halfpenny, the halfpenny will appear nearly as large as the penny.

Another everyday proof. Let a person sit in one end of a long punt with parallel sides, and look at the other end—it will look to him to be wider than where he is, and yet its sides will by perspective laws vanish quickly away from him.

These proofs show the effect of binocular vision, which is to increase the appearance of height and to narrow the appearance of breadth. Consequently it makes objects appear taller than a perspective drawing would do.

Deduction.—The reason we get a different impression of relative sizes of objects by normal vision from that given by mathematical perspective drawing and photographs is that the combination of these properties of vertical and horizontal visions give quite a different result to that of perspective drawings.

Final.—Having shown how we see forms, it only remains to say that a mathematical perspective drawing or the drawing of an aplanatic photographic lens does not give forms as we see them. They are altogether false to the visual impression of the proportions of things, and therefore give a wrong idea of the original scene. On the other hand, a perspective drawing or correct photograph gives the *actual facts* scientifically, *i. e.*, the pillars of the temple as leaning, the paper in experiment as *square*. All such drawings are, therefore, purely scientific diagrams, and artists who wish to render what they see must not rely upon them.—*Photography.*

* We have ignored for the sake of simplicity the optical law of inversion of the image on the retina ; when that is considered, the terms "upper" and "lower" must be merely interchanged.

A NEW ANTISEPTIC.

AT the Académie de Médecine, Paris, on April 28, M. Polaillon read a paper contributed by Dr. Berlioz, of Grenoble, on a new antiseptic agent called "microcidine," which is composed of seventy-five per cent. of naphtholate of sodium and twenty-five per cent. naphol and phenyl compounds. According to the *Lancet*, it is a white powder obtained by adding to fused β-naphthol half its weight of caustic soda, and allowing the mixture to cool. It is soluble in three parts of water, and the solution, which is cheap, is said to possess considerable antiseptic powers, without being toxic or caustic, or injurious to instruments or linen. The

antiseptic properties of microcidine, while inferior to those of corrosive sublimate or naphthol, surpass those of carbolic and boracic acids ten and twenty times respectively. Microcidine is eliminated by the kidneys, and is antipyretic. M. Polaillon has experimented with this new agent largely as a dressing to recent and other wounds, utilizing as a dressing, after a preliminary cleansing of the raw surface with a three per cent. solution, gauze soaked in the same and covered with a layer of oil silk and a thick pad of cotton wool. The results are reported to have been excellent.

APPARATUS FOR STERILIZING MILK.

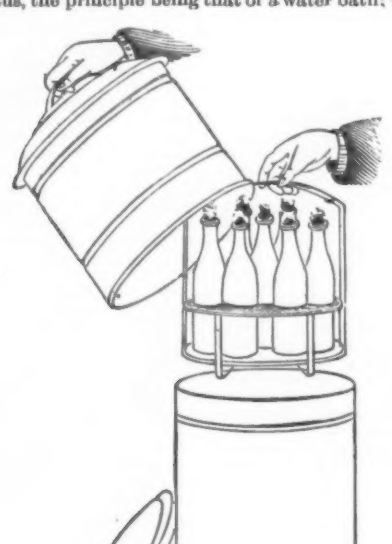
DR. T. M. CHEESMAN read before the Section on Pædiatrics of the New York Academy of Medicine a paper on this subject.

He recommends the Arnold steam sterilizer, illustrated below, believing that this presents these principal advantages: (1) Effectiveness in sterilizing; (2) economy, both of time and fuel; and (3) great convenience, on account of its portability.

ARNOLD STEAM STERILIZER.

The sterilizer consists of (1) a flat shallow boiler, holding but a small amount of water, and therefore requiring but a minimum amount of heat to produce steam; (2) a reservoir which constantly feeds the boiler and causes steam to be formed continuously; (3) the steam chest or receiving vessel; and (4) a hood inclosing a space between itself and the receiver, which is constantly supplied with escaped steam, a device which causes a temperature once reached to be maintained so long as the heat is unchanged.

Sterilization is accomplished by bringing the object to be sterilized to the temperature of live steam, and maintaining it for about forty-five minutes. Boiling for the same length of time, in a vessel, the sides of which are exposed to the air, is not efficient, as the temperature in different parts of the vessel varies considerably. This is the main objection to Soxhlet's apparatus, the principle being that of a water bath; while in the sterilizer we have steam bath in which variation of the temperature is prevented.

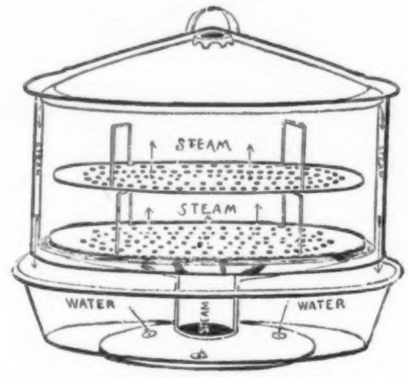

ARNOLD STERILIZER IN USE.

Numerous tests have shown that with a single Bunsen burner, and ordinary gas pressure, the temperature of 212 degrees Fahrenheit is reached in all parts of the receiving vessel in less than ten minutes. The time required to raise the fluid to be sterilized to the same temperature is found to be directly proportional to its bulk, so that less time is required when the food is in divided quantities. When the temperature of 212 degrees Fahrenheit is reached, sterilization has commenced, and should be continued for forty-five minutes, which time is necessary on account of the great resistance of the spores.

The recommendations to any one who might use it are as follows: That the food be prepared as it is to be administered, and that the quantity required for twelve or twenty-four hours' feeding be distributed in eight ounce flasks or nursing bottles, providing one such bottle for each feeding, so that no unnecessary exposure or transference shall be had. In filling the bottles a funnel should always be used to keep the necks clean, and the fluid should be a full inch below the neck. The bottles should be plugged with cotton, extending well down into the neck, any impurities which this may contain, in the form of moulds of bacteria, being destroyed by the same process which sterilizes the food. The bottles are now placed in the cold receiving vessel (to prevent breakage), and heat is applied by means of gas or a kerosene or coal stove. To insure a complete sterilization, heat should be maintained altogether for one and a quarter hours.

Food thus prepared can be kept at ordinary temperatures for an indefinite period, doing away entirely with the use of an ice pail or refrigerator for keeping the milk sweet.

When the food is to be given, the bottle is to be well shaken to mix in the cream, the cotton plug is removed, and the nipple applied to the bottle at once. In cases where it may be necessary to administer food at a higher temperature, the bottle is stood in warm water, as is customary. In regard to the nipples, it is not practicable to sterilize them, as heat destroys the rubber, but they can be thoroughly cleansed by the ordinary methods.—*Bulletin of Pharmacy.*



SPECIAL INSTRUMENT STERILIZER.

THE USE OF GAS FOR VENTILATION.

IN an article communicated to the London *Journal*, Mr. Thos. Fletcher, F.C.S., remarks that, as in many other applications of coal gas as a fuel, its use for the purpose of ventilation has been, up to the present, without any system or knowledge of the proper conditions necessary; and I have for this reason undertaken a series of experiments with the object of determining the laws which rule its application. An examination of the table given below will show some curious and unexpected facts.

It is, of course, well known that for ventilation, or for heating a body of air, the available duty of a luminous or an atmospheric burner is precisely the same; and the choice is purely a matter of convenience and suitability for the conditions necessary. First of all we must consider the fact that burners for this purpose are generally placed in a position where they are difficult or inconvenient to get at and examine; and they are liable to be left for years without any attention. They are also subjected to strong vertical currents; and, when not required, must be capable of being turned down, with a by-pass, to a small pilot light, to prevent the necessity of relighting. All these conditions point to the desirability of using small ordinary union jets; and the table shows that the quantity of gas required for any ventilating shaft is remarkably small. When this quantity is exceeded, the duty obtained from the excess is so little that, under ordinary circumstances, the extra gas may be considered almost as wasted.

There is one source of error in the experiments, which I have found it impossible to entirely eliminate—the fact that I have been unable to obtain a portable and convenient meter which accurately indicates fractions of cubic feet; and the attempt to correct this by long runs has made the experiments most tedious, lasting over a long period. The meter used registered, on an average, 1 per cent. fast; but all the other instruments were absolutely correct. The anemometer was verified, and the correction tables were used; the chronograph was perfect; and the thermometer was recently verified for the purpose. To prevent any doubt as to the choice of burners, the experiments were repeated under exact conditions alternately with a gauze atmospheric burner, and with a flat flame—both burners being used under pressures varying from $\frac{2}{10}$ to $\frac{12}{10}$; and the results with each form of burner, under all pressures, were absolutely identical.

VERTICAL FLUE, 6 INCHES DIAMETER, 12 FEET HIGH.

Gas burned per Hour. Cubic Feet.	Speed of Current per Minute. Feet.	Total Air exhausted per Hour. Cubic Feet.	Air exhausted per Cubic Foot of Gas burned. Cubic Feet.	Temperature at Outlet. Normal 62° F.
1	205	2,460	2,460	82°
2	245	2,940	1,470	92°
4	325	3,900	975	110°
8	415	4,980	622	137°

With precisely the same arrangements, but with the flue cut down to 6 feet in height, the available duty was reduced 20 per cent.

Taking the experiments as a whole, it will be seen that, in a flue 6 inches in diameter, the maximum speed of current which can be obtained with economy is about 200 feet per minute; and this was realized with a gas consumption of 1 cubic foot per hour—1 cubic foot of gas removing 2,460 cubic feet of air. To double the speed of the current, it was necessary to burn 8 feet of gas per hour—eight times the quantity; and the effective duty per cubic foot of gas burned dropped to one-fourth.

It is a very common thing to see a ventilating shaft, 6 inches or less in diameter, with burners under it consuming from 15 to 20 cubic feet of gas per hour; and it is quite evident that the greater part of this is completely wasted—in fact, in many cases it is worse than wasted, as the extra heat evolved is often very objectionable when radiated from the flames and the external surface of the shaft. The heat escaping at the top of the flue varied from the equivalent of 49,200 cubic feet heated 1° F. to 373,500 cubic feet heated to the same extent: the amount of heat escaping increasing in regular proportion to the increase in the gas consumption.

These experiments establish the following important facts: That the maximum consumption of gas in a ventilating flue should not exceed 5 cubic feet per hour for each circular foot area of section; that the effective duty of atmospheric and illuminating flames is the same in all cases where a large quantity of air has to be heated to a low temperature; and that the consumption of 1 cubic foot of gas in a ventilating shaft can be made to remove more than 2,400 times its own bulk.

The advocates of the so-called "destructors" for sewer ventilation carefully avoid any positive statements and figures, and we are led to believe that a consumption of gas equal to 8 cubic feet per hour will heat 250 cubic feet of air per minute, or 15,000 cubic feet per hour, to temperatures varying, according to the imagination of the observer, from 400° to 600° F. As a matter of fact, such a result is a total impossibility; and the heating of a limited surface to 400° or 600° F. by no means insures either the heating of the surrounding air to anything approaching this nor does it insure the destruction of all the germs contained in the air. The experiments detailed above show clearly that, with a large bulk of air and a small gas consumption, high temperatures are impossible; and the mistake has arisen from jumping at the conclusion that, if air is passed through an apparatus heated to 400°, all the air must be heated to this temperature, which is by no means a necessary consequence. It would be desirable that the "destructors" should be tested by an analysis of the air before and after passing; as, judging by the foregoing experiments, it would appear that the average rise in temperature in the "destructor" shafts would be only 25° F., provided that the specified quantity of air is passed.

RESUSCITATION FROM DROWNING.

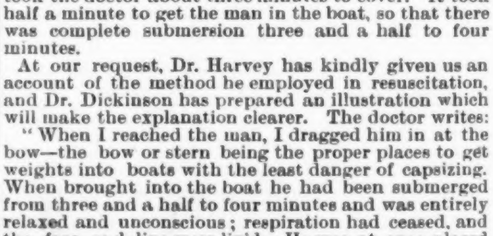
OUR readers will doubtless recall the sad accident which occurred at Red Bank, N. J., some time ago, in which a boy was drowned, and his father saved by the medical skill and common sense of Dr. E. J. Harvey, a graduate of Long Island College Hospital and a former practitioner of Brooklyn.

The facts were as follows:

The father and son had gone out fishing in a canoe of the Rushton pattern, and in some way not yet explained, the boat overturned and they both fell into the water. Dr. Harvey happened to be out rowing at the time the accident happened, although he saw nothing of its commencement. When he first noticed the man in the water, he thought he was bathing; but as his body, or rather shoulders, at times seemed to be thrust higher from the water than a swimmer would naturally do, and as he in a little time disappeared from view altogether, Dr. Harvey determined to row to him, though he was not at all sure but that he would find an ordinary bather swimming about a boat. The distance to the man was about a quarter of a mile, and took the doctor about three minutes to cover. It took half a minute to get the man in the boat, so that there was complete submersion three and a half to four minutes.

At our request, Dr. Harvey has kindly given us an account of the method he employed in resuscitation, and Dr. Dickinson has prepared an illustration which will make the explanation clearer. The doctor writes:

"When I reached the man, I dragged him in at the bow—the bow or stern being the proper places to get weights into boats with the least danger of capsizing. When brought into the boat he had been submerged from three and a half to four minutes and was entirely relaxed and unconscious; respiration had ceased, and the face and lips were livid. He was at once placed upon his back, his shoulders on a thwart, his neck unsupported, and the back of his head resting upon the bottom of the boat, some five inches below, the upper surface of the thwart supporting the shoulders. The arms were extended beside the head, as in the Sylvester method. The clothing was removed from the neck. The position was something like this:



"As soon as the head was thus depressed, a quantity of water poured from the mouth and nostrils; this flow of water was increased by lifting the shoulders from the thwart and still higher above the level of the head. When the flow stopped, the patient began to gasp; his shoulders were then replaced on the thwart. Breathing was gradually re-established. At first a good deal of foam and mucus obstructed and issued from the mouth and nostrils, and were wiped away; in a short time they ceased to form.

"It must have been half a minute, after getting him aboard when the patient began gasping. It was my intention to use the Sylvester method of artificial respiration, but as the respiratory efforts continued and increased in frequency, I allowed the arms to remain

extended and did not flex and compress them against the chest.

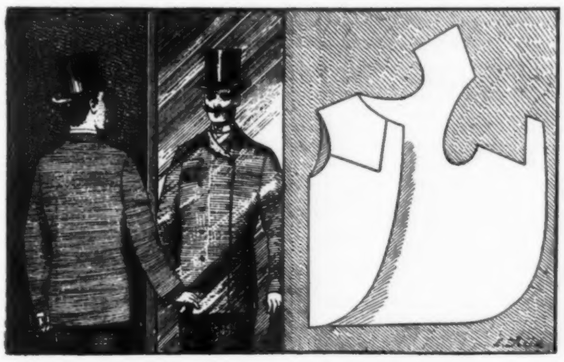
"As soon as respiration was firmly established, though stertorous, the unconscious patient was brought ashore and got into bed. He was then put in the care of his family physician. I am told that he did not recover consciousness for five hours after the accident, and that hypodermic injections of stimulants, etc., were used. He is about thirty years of age, of medium weight and size, and was not in very good health nor well nourished at the time of the accident."

In "Holmes' Surgery," vol. v., p. 906, Wood's edition, 1875, in a report made by an English committee, they state: "When the head of the subject was allowed to hang back over the edge of the table, air seemed to pass into the chest more readily than when the back of the head rested upon the table." In the case just related, the elevation of the thorax and the depression of the head appear to have been of good service.

The method adopted by Dr. Harvey is so simple and so easy of application that we feel it a duty to call the attention of our readers to it, at a season of the year when drowning accidents are so frequent.—*Brooklyn Med. Jour.*

JACKET WITHOUT SEAMS.

OUR engraving shows quite an original invention, the object of which is to do away with seams in jackets, overcoats, etc. The patterns to the right

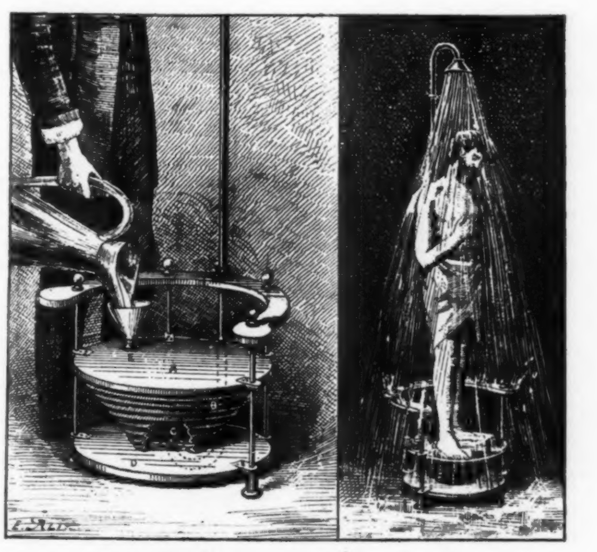


JACKET WITHOUT SEAMS.

show the method of cutting the cloth and afterward folding the pieces to form arm holes, and which are sewed according to the dotted line shown in the figure to the left. As one of these lines is hidden by the overlapping of the left breast of the garment and the other is concealed by the flap of the breast pocket, it results that no trace of sewing is perceived.—*Les Inventions Nouvelles.*

PORTABLE SHOWER BATH.

THE annexed engraving represents an apparatus that is capable of rendering many services in the



PORTABLE SHOWER BATH.

country where there is no water pressure at one's disposal, and which has the great advantage of being easily carried about, and set up anywhere. It consists of a reservoir, B, in the form of a bellows, provided with a wooden or metallic cover, and fixed at the bottom upon a platform, D, provided with an aperture into which enters the curved extremity of a pipe in which the water rises. Water is introduced into the reservoir through an aperture, E, which, being plugged up after the apparatus is full, the bath is ready for use. It suffices to step upon the cover to have the weight of the body cause the water to rise in the pipe. A series of guides fixed upon the cover and sliding along the uprights of the apparatus keep the cover horizontal during the descent.—*Les Inventions Nouvelles.*

[Continued from SUPPLEMENT, No. 810, page 12949.]

THE MISSISSIPPI RIVER.*

By JACQUES W. REDWAY.

LET us turn again to the great outlet and commercial highway, and study its physical geography. A glance of a moment will teach us that, in addition to its beneficence as a builder of the great basin which bears its name, and a fertilizer of the valley through which it flows, it is also a destroying agent, which at times spreads ruin and disaster from source to mouth. In order to better understand the capricious conduct of a stream which one minute builds land and the next tears it away, let us follow the course of the stream from its sources to its mouth.

Its beginnings, like those of every great river, are high in the snow-capped ridges of the Rocky Mountains, and among the lake-dotted crests of the *Hauteurs des Terres.* The former region is clad in almost eternal snows; the latter is diversified by a multitude of basins, dug out by the glaciers that were once pushed down from the icy North. In both regions there is an abundance of snow and rain, and here of necessity springs are most numerous. The water that trickles from some spring, or from a winter's drift of snow, forms a little rill that tumbles in silver-streaked cascades down the mountain slope to the plain below. On its way it is joined by other rills in their journey oceanward, and the rivulet thus formed rushes through the self-worn, pebbled gullies. Other streams, which in a like manner have gathered into narrow channels, swell the flood into a mountain torrent. It now plunges over cliffs and rolls down deep inclines, cutting its channel through hard rock, tossing aside or carrying with it obstacles that it may encounter, seizing atoms of earth here or dropping them there, accordingly as its velocity is increased or diminished. From the moment the rivulet leaves the snow bank and touches ground, its waters are loaded with silt, and as they whirl along the mountain ravines, they gather more and more, until each drop has grasped all that it can possibly carry. A slight increase in the velocity of the current will enormously increase its carrying capacity. Double the rate of flow and the water will carry sixty-four times† as much burden, or it will move pieces of rock sixty-four times as large. Now, if such a slight increase in velocity adds so much to the carrying power of the current, it is evident that checking the velocity will cause an extraordinary deposition of sediment; hence the reason that a bar forms so quickly whenever a snag or other obstacle anchors in midstream.

When the water has reached St. Louis it is still loaded with silt. It is still 1,300 miles from the Gulf of Mexico, and it has from 375 to 400 feet to fall, accordingly as we consider it the time of the spring rise or that of the summer low stage. Below St. Louis it flows with slightly decreasing velocity. That means that the river flows over ground which the water itself has deposited. Along this extent there are no banks which the river has not built for itself, and because it has built them, it can just as easily tear them away. The water is always charged with material which one moment may be a building substance and the next a cutting tool. If the current be ever so slightly checked the water must drop more or less of its load, and because the burden cannot be borne by the water, the river must of necessity flow around it. Along its lower course the changing seasons have brought successively so many floods and droughts, it is so deeply silted up, that the river, now lifted above the walls that once restrained it, wanders lawless and ungovernable in the broad valley, almost whithersoever it will.

The whole of the lower part of the valley is covered with alluvial sediment, which in some places is more than a thousand feet deep. In ages past the river must have flowed in all parts of the lower valley, doing then just what it is doing to-day—making banks and cutting them away; spreading out in sinuous curves and then cutting a new channel across the narrow neck; making then the same crescent-shaped moats that it makes now; silting up its channel in one place to cut a new one in another, making bars and towheads in seasons of low water and cutting them away in time of flood; shifting Arkansas into Mississippi at one time and Mississippi into Arkansas at another. When the Gulf of Mexico extended as far north as St. Louis, the Missouri behaved just as the Red River must have done only a few years since. At one period the waters of the Missouri flowed into the Mississippi, at another they repudiated their channel and flowed into the Gulf.

From St. Louis to the Gulf, the river has a fall of little more than three inches to the mile. Were it to flow as the crow flies, it would have a fall of seven inches per mile. Why it does not straighten itself seems at first thought singular, until we recollect that the current is well filled with sediment, and that it flows over ground with a constantly decreasing slope. Because of this we see that the river cannot longer even carry its burden, much less erode and carry more silt. It must, therefore, drop a part of its burden and flow around it. This it does in time of low water; but when the spring floods come, the rate of flow is increased, and the current goes to work straightening out curves, cutting away bars, and scouring out its old channel, or making a new one. So sensitive is the silted channel to the amount of water it bears that the length of the river between Cairo and tide water might almost be taken as measure of the rainfall in the basin which it drains, lengthening its channel during seasons of drought because of decreased volume, and shortening when spring floods swell its tide. The variation in the volume of the river between low water and flood stages is almost incredible. The average width of the river, at mean stages, is about one mile;* during the spring floods, between Cairo and the Gulf, it is from twenty to fifty miles wide. Most of this is, of course, back water, flowing at a very gentle rate or, perhaps, remaining stationary until the flood begins to fall along the main channel. Were this entire flood to flow through the valley at the rate which a slope of seven inches per mile would impart, the problem of controlling the river would be very quickly solved—there would soon be no valley left. Thus we see that the problem is one of great extremes; it is a question of how to control a stream which at one season is a river, and at another an ocean. Above St. Louis the river will take care of itself; below that the problem is a serious one.

The character of the made land is an important factor in the case. The river has a wonderful sorting power over the sediment it brings down. It is hardly necessary to say that the heaviest detritus will be the first to be dropped by the current, and that the silt having the lowest specific gravity will be longest held in suspension. The bottom lands are made of the latter. This sediment is chiefly mineral substance. From long attrition its grains are so fine and impalp-

* Read May 17, 1890, before the Engineers' Club of Philadelphia.

† This law of the transporting power of running streams is mainly deduced from the investigations of Prof. Jos. Le Conte (El. of Geol., p. 19). In the case of the heavier gravel left on the river bars by the sorting power of the current, I believe that the actual value falls far short of the theoretical value, from the fact that there is no little cohesiveness existing between the substance to be removed and the surface of the river bed. With the lighter silt, such as is found in the Missouri and the lower Mississippi, the theoretical value is nearly attained. The following is a synopsis of the deduction as given by Prof. Le Conte.

If the surface of the obstacle is constant, the striking force of the water varies as the square of the velocity.

$$f \propto v^2 \ldots . (1).$$

This is evident from the fact that if the rate of flow be doubled, not only will the current strike the obstacle with twice the velocity, but twice as much water will strike the obstacle in the same length of time; that is, *doubling* the velocity *quadruples* the force of the current.

Now, if the velocity remains constant while the size of the substance increases, then the force of the current will vary as the surface of the substance varies in size; that is, if the surface is doubled, it will require twice as much water to move it. In general, we may say it varies as the square of the diameter; that is,

$$f \propto d^2 \ldots . (2).$$

But if the velocity of the current and the size of the substance *both* vary, then we have--multiplying (1) and (2):

$$f_1 \propto v^2 d^2 \ldots . (3).$$

Now the resistance of the stone, which is practically its weight (W), varies as the cube of the diameter; that is,

$$W \propto d^3 \ldots . (4).$$

The case in consideration is that the force of the current must be able to just move the stone; that is,

$$f_1 \propto W \ldots . (5).$$

Then comparing (3) and (4) we have

$$d^3 \propto v^2 d^2 \ldots . (6);$$

or, dividing by d^2,

$$d \propto v^2 \ldots . (7).$$

Substituting in (3) the value of d, we have

$$f_1 \propto v^4 v^2; \text{ or, } f_1 \propto v^6.$$

* The greatest width of the river, singularly, is not in the lower, but in the middle, course. Almost everywhere between St. Louis and Rock Island the width is greater than at points below St. Louis or Cairo. Above the latter point the river *receives* tributaries; below it, it begins to *give them out*. That is, its current, instead of flowing in a single channel, splits up into many. The reason is obvious: the river is flowing over made land, which of necessity has but a very slight slope; and hence the current is so slow that it cannot scour out a deep or a wide channel. On the contrary, it is constantly adding fresh detritus instead of removing it. The offshoots of the river are commonly known as *bayous*. On the lower part of the river these are so numerous, and form such a complex network of channels, that none but the most expert pilot can find his way among them. During the civil war, when competent pilots were not always to be found, government transports and dispatch boats were not infrequently lost among the tortuous cuts and bayous. In regard to the extent of its bayous, the Mississippi is not unlike other large rivers. On the Amazon, bayous are so numerous that one can ascend the river a distance of over a thousand miles without ever touching the main channel more than once or twice.

able that it is almost soluble. Moreover, because of the large percentage of organic matter with which it is intimately mixed, not only is its specific gravity considerably lessened, but all cohesive qualities it may once have possessed have disappeared. It, therefore, is scarcely heavier than the water itself, and, when wet, is not more cohesive. In the construction of levees and other embankments, this treacherous material is used almost exclusively, for the reason that there is no other at hand. When Captain Eads was building the jetties which have given South Pass a greater depth of water than it ever before had, he found that he could successfully employ this material for embankments only when it was held down by mattresses of willow and pinned *in situ*.

How, therefore, shall a stream varying from one to fifty miles in width be kept between banks that have no power to resist erosion and corrosion? Human ingenuity has overcome many apparently insurmountable difficulties, but it remains to be seen whether it is able to cope with this problem. Because Eads' jetties have successfully controlled a few miles of that part of the river easiest to remedy, the cry has gone forth, "Let us jetty and revet every part of the river that overflows its banks; let us have levees solid as stone, and high as the floods. The old levees of *ante-bellum* days were good in their way; let us rebuild them and make them stronger and higher."

With the mere allusion to the fact that this cry has been sounded mainly from quarters at a distance from the scene of trouble, let us consider the theory in the light of past history. This, if we take the experience of French engineers, has shown, 1st, that if the stream be leveed so as to prevent overflow, it is ruined for purposes of navigation; 2d, if the levees are constructed for the purpose of improving navigation, overflows are not checked. Now the problem in the case of the Mississippi is how to accomplish both. With a system of levees, the end to be desired is to maintain a current that shall not be rapid enough to cut away banks, and too rapid to permit the deposition of sediment. In order to do this the channel must be lengthened when the current is too rapid and shortened when a greater velocity is desired. Now, if the slope and the volume of water were uniform throughout, the accomplishment of this would be a question of money and time only. But, inasmuch as the slope is not uniform, and because the volume and velocity are not the same during any two successive months of the year, permanent levees can be of service in but few places only. When the river lengthens its channel into a long loop, it only follows natural laws. When it breaks through the loop, it is also following natural laws.*

We are thus brought face to face with the fact that the Mississippi of high water is physically a different stream from the Mississippi of low stage—the flood stage being distinguished by a very wide and comparatively straight channel, the low stage by a narrow and tortuous channel. A scheme for permanent improvement must therefore involve the plan of keeping the low water channel within the limits of the high water banks. We are also brought to a consideration of the so-called "common sense" theory that has been advanced from time to time. This is a general panacea which practically aims to correct the meandering of the river by straightening the channel, and it is to be accomplished by cutting canals across loops which show a disposition to lengthen, and by constructing levees in such places where the channel manifests a disposition to meander. Let us look a moment at this proposition. A river begins to form a loop because its velocity of current is decreasing. It cannot carry the sediment its waters contain; and because it cannot carry the load, it must drop a part of the latter and flow around it. Cutting a canal across the loop will increase the slope of the channel, and therefore increase the velocity to a scouring or corroding degree. And herein lies the trouble: the scourings from this cut-off must be deposited at some point below, where the slope is less and the current weaker. In other words, a loop is straightened away in one place, only to be formed in another lower down the stream. Another objection is that at a cut-off like that of Palmyra Bend, the velocity of the current was increased to the point where it became highly destructive to surrounding lands. It is, of course, claimed that the increase of velocity is only temporary, and that sooner or later the current would become slower, and thus regain its former condition. But the river can regain its former slope and velocity only by regaining its former length.† Thus the cut-offs that have occurred from time to time in the lower Mississippi have not permanently shortened the river; they have, however, caused more disaster than an average flood. When such a cut-off has been made with a view to shortening the distance between river ports, the intention has generally been defeated by the creation of rapids, which form an obstacle to navigation greater than that of the former loop. The engineering schemes to improve the Rhine, Danube and Loire‡ have in many instances proved detriments rather than aids to the navigation of those streams.

Another "common sense" plan is that the channel should, in every case, be held along the bluffs. The main idea of this scheme is that the bluff presents a firm, unyielding texture, which is much less subject to corrosion than the self-deposited alluvium of the bottom lands. This plan, when examined, does not differ materially from the preceding idea of canals and cuts. The fact that the river meanders away from the bluffs is in itself evidence that it does not naturally flow next to them. Moreover, the bluff escarpments follow a tolerably straight line, and this makes the factors of the problem still more like those of the preceding. It would, therefore, be as difficult to hold the river against the bluffs as to force it to flow in a straight channel. A still greater difficulty would arise in the destruction of landings. Under such a plan of reconstruction all permanent landings must be obviously on the bluff side, and furthermore, they must be situated at such places where breaks and openings permit access to the river. Not only would such places necessarily be inconveniently distant from produce-raising centers, but the opposite side of the river, because of its alluvial banks and approaches, would be cut off from access to deep water. This would of necessity cause a general change of landing places and lead to the payment of heavy indemnities for individual losses. Therefore, inasmuch as the government can appropriate money only for the improvement of navigation and the development of commerce, and not for their destruction or discouragement, it is evident that this scheme of improving the river is out of the question.

With our present knowledge of river hydrography it is rarely ever suggested that a wholesale revetment of the banks would be a proper remedy. The history of past experiences has proved too practical a lesson to leave any room to doubt the outcome of such a step. Wherever this has been done, the bed has been invariably raised above the surrounding land, and disastrous inundations have resulted.

During the past decade the government, through the Mississippi Commission, has undertaken extensive operations for the improvement of the lower river. These operations have been of two kinds: 1st, a series of levees and revetments along the flood plain; 2d, the ponding of waters at the sources of the river by dams.

That any extensive system of revetment or jetting should be relied upon as a permanent improvement, in the light of modern engineering science, seems almost like flying in the face of Providence. It is hardly proper in these pages to describe in detail the location and amount of levee and revetment work that has been done. Let us rather consider the opinions of two river experts—one an eminent engineer, the other a river man.

Mr. William Elseffer, the engineer, says: "The Mississippi River is gorged for 600 miles, from Helena, Ark., to the head of the passes below New Orleans. The causes of this gorge are the obstructions that have been placed at a number of points, especially at Plum Point reach, above Memphis; at Lake Providence reach, above Vicksburg; in the channel of the river, at New Orleans; the jetties at the mouth; together with other works in the channel and on the banks. These works have been constructed at a cost of ten or fifteen millions of dollars. The effect of such works has been to narrow the channel and to cause the deposit of sedimentary material, which obstructs the discharge of flood waters. It is easy to demonstrate by the principles of hydraulics that the construction of these works has gorged the river and raised the flood waters. There is no question whatever that the river has been dammed. Captain Eads testified before the committee of Congress that he had placed these dams at the mouth of the river and at the passes. The effect has been to obstruct the river as far up as the Red River and Vicksburg."

Concerning the treatment of the lower river, Mr. Elseffer continues: "The methods of the Mississippi Commission have been entirely unsound and based upon erroneous principles of river hydraulics. Their method has been to narrow the channel and to contract the flood volume. Their constructions give a higher level to the flood, and hence there will be continual caving in of banks and overflowing of levees. The channel of the river will be injured not only for the discharge of the flood volume, but for low water navigation. If you attempt to discharge a given volume of water, in a given time, through a smaller pipe, you must increase the head or pressure and hence the speed of the flow. So if you contract a river channel, you increase the speed of the current and hence the friction against the banks.

"The facts about the condition of the lower river for the past few years fully demonstrate the truth of my assertions. In 1887 the Mississippi River went lower than for twenty years. It was a season of uncommon drought throughout the valley. At Vicksburg, during November of that year, the river averaged five feet lower than during the same month of the previous year. But at New Orleans the river was an inch higher in November, 1887, than in November, 1886, showing that the jetties and other obstructions impeded the flow of the stream.

"General Humphreys, in 1859, gauged the river at New Orleans and found that it discharged 1,100,000 cubic feet per second. I see that the Mississippi River Commission, in its report for 1884, says that the river discharged about 960,000 cubic feet per second, showing a reduced capacity in the river to discharge the flood volume as the result of the artificial obstructions which have been created. But it is stated that the river at the latitude of Red River discharged during the flood of that year at the rate of 2,100,000 cubic ft. per second. This accounts for the overflows and crevasses between the two points. With the decrease in capacity there has come some increase in the speed of the current at New Orleans.

"The danger is increasing from year to year from natural and artificial causes. There are no longer the forests and swamps to hold back the waters from slowly melting snow. Thirty or forty years ago floods in the lower Mississippi usually came as late as June. Now they come in the spring. The obstructions constructed by the government have aggravated the danger until the present situation is one of great peril. If there should come another rain or flood in any of the tributaries of the river within a week or two, to add to the volume of the flood now on its way to the Gulf, the peril to New Orleans and of all the territory in the lower valley would be apalling."

From the opinion of our expert hydrographic engineer let us turn to that of Captain Thomas Leathers, a veteran river man. To a correspondent of the New York *Times* he said:

"I have watched the river for fifty-three years as captain and pilot, and have had licenses as both all that time. I think it is my duty to inform the people of the valleys of the grievance and wrongs which exist. They have patronized me for fifty years, and I am grateful. During my years of service I have noticed all the work which has been done on my beat. I consider that the first great injury done to the river was stopping up the Southwest Pass and Pass-a-l'Outre to obstruct the flow of water to the Gulf. The river rises and falls four feet at the head of the passes to every sixteen feet of change here—four to one. At Vicksburg the difference is three to one as compared with New Orleans, so that four inches of rise here gives one foot of rise there.

"The second mistake has been the contracting of the sides of the river by the commission, contrary to engineering claims. The elevation of the surface causes the bottom to fill. That has been the result of the great work at Providence and Plum Point Bend, where numberless piles have been driven and mattresses put down. The rise and fall of the water at Cairo is 51½ ft., and it is also that at Vicksburg, where it wants 5½ ft. of high water, and I am satisfied that the gauge is not right, while at Memphis and Plum Point it is only 36 ft. At Plum Point the river is very wide, and the St. Francis Swamp has been a drain for it. Now, the River Commission has contracted the river there to one-half its former width, and the St. Francis Swamp has a levee across it for the Arkansas Railroad, forty-two miles in width. It stops the flow of water there, and the further contraction at Plum Point Bend, where there is only thirty-six feet fall, does not leave sufficient capacity for the river to flow. It is the same contraction as in Providence Beach and that vicinity.

"At Cairo the Kentucky Swamp has been leveed by the railroad. There is a deep swamp there, five miles wide, and its filling up stopped the flow of water there. Besides that, there has been a bridge put across there now. The bridge stops the flow of water between high and low water, and there is at least 3,000 cubic feet resistance from that cause alone. If there is a bridge to be placed at Memphis also, I presume that, the river being wider at that point, there will be more piers, and consequently more resistance.

"From my standpoint and my observation it is impossible to get rid of the water with the present stopping up of the river at its mouth and above. All the piers are on alluvial bottoms and stop the flow of the water just in proportion to their front face, and that means the elevation of the river just that much. The River Commission is claiming the deepening of the channel by contracting the surface; but I know that it is exactly the opposite. I know that the gauge to-day reads 44 feet at Natchez and 46 feet at Vicksburg: that is 5 feet below high water at Vicksburg and 6 feet at Natchez. But I also know that what they call the zero gauge, which is intended to represent low water, does not go to low water. The gauges have been moved up. I have practical proof that the gauges are not correct. In the case of my little boat, last October we had to restrict her capacity to 7½ feet, so that she could come through at St. Catharine's Bar, twelve miles below Natchez. For fifty years there never has been less than 9 feet of water there, but now the depth is less. At that time the gauge showed that there was 3·30 feet wanting to low water; still there was only 7 feet of water in the channel. That shows a clear fall there of 6 feet, or at least the bottom had filled up that much last October.

"I would like to give my advice. If the government intends to stop the navigation of the river by building low bridges and overflowing the valley, I would advise that steamboat navigation be dispensed with entirely and that pontoon bridges be built in place of those now existing. It would make little difference to steamboat men, as they find it impossible to run 100-foot steamboats through 50 feet of space given by low bridges. I have never seen a steamboat that could go under the Cairo bridge during high water, for there is only 53 feet of room. Pontoon bridges will, at least, not obstruct the flow of water.

"In conclusion, I know that there is not more than 50 per cent. of the capacity to discharge water at South Pass that there was the first day Mr. Eads went there. The channel to-day is not large enough to discharge the Kanawha River when full."

The construction of reservoirs for the ponding of the excess of water over that required for a full channel, although an experiment, is certainly one worth trial, and it has the advantage of not conflicting materially with the laws of river hydrography. It is evident that a river changes its channel but little when the volume of water—and, therefore, the velocity of current—is constant. Changes that occur under such conditions are tolerably uniform in action, and can be foretold with a fair degree of certainty. The design of the reservoirs is, in brief, to keep so nearly a uniform volume of water in the channel at all periods of the year that the river shall never be more than bankfull at the flood season, reserving local work to the removal or improvement of the more troublesome bars.

With the bars once removed and the channel cleared out, it is evident that the plan of keeping a uniform volume of water will result in a more permanent channel than any other method of improvement. Because low water stages indicate a lengthening channel, and flood seasons a shortening channel, it is obvious that a uniform volume of water indicates a channel whose variations in length are reduced to a minimum. This once accomplished, engineering skill will be directed mainly to the clearing of bars—for, as long as the river bears silt, bars will form and travel down stream*—and the protection and strengthening of the banks.

* An old flat-boatman said, "When God Almighty made this yer river, He told it to go where it wanted ter," adding, by way of a climax, "and it has always went thar." The boatman's language may have been metaphorical, but his ideas were correct. Had he been a hydrographic engineer, he would have said that the channel shifts as the volume and velocity of flow change, following in every case the line of least resistance.

† Or by lowering the bed from the foot of the rapids to a point considerably beyond their beginning.

‡ The Garonne and the Loire have been almost wholly ruined as navigable water courses by ill-advised schemes contrary to every principle of hydraulic engineering.

* "If we imagine a perfectly straight channel with immovable bed and banks, but partly filled with sand, through which a constant stream of water flows with a velocity sufficient to move freely the sand below it, the effect will, of course, be to entirely remove the sand. If, however, the latter is supplied in sufficient quantity to compensate for that removed, the experiment will more nearly resemble cases met with in ordinary practice. Under the action of the flowing water the sand will be found to form a series of ridges, like long, shallow waves, which move forward with a velocity considerably less than that of the water itself; the rear slope of the waves being very long, while the front is usually shorter and may be quite abrupt. The sand rolls up the rear slope and falls over the crest, and in this manner the wave advances. The velocity at the sides of the channel must be less than at the center, on account of the friction of the sides, and a moment's reflection will show that a greater mass of sand will be moved by the central current, and, therefore, that the length of the sand wave, measured on lines normal to its crest, will be greatest at the center and least at the sides. Again, if the sand is not homogeneous, the heavier grains will be more readily moved by the strong current in the center of the stream than by the weaker current at the sides; hence the heavier sand will be accumulated at the center of the wave, and the lighter material found at its sides. Now, let us suppose the supply of water to be diminished, until the decrease of velocity and scouring power render it unable to move the sand. After a short time much of the water will be drained off, leaving the sand waves stretched across the channel like a series of dams, ponding the water above them. The water remaining will flow over these dams in a shallow sheet, which will diminish in depth as the level above is drawn down, and by a continuance of this action a sensible difference of level between water on the two sides of the dam is developed. When the head attains sufficient magnitude, the waters will make a breach in the dam to find an outlet, the velocity of the head determining the part of the dam broken through. It evidently will not be the middle part, because, as already explained, this must, from its com-

The plan, in brief, whereby the uniformity of volume is to be secured, consists of the storage of the surplus water which accumulates during the spring floods. The storage of the surplus water in the reservoirs at the head of the river and its upper tributaries will not only lessen the volume of water floods which occur at the breaking up of the winter season, but it also furnishes a supply to be drawn from during the low stage of summer and fall. The reservoirs for the storage of the surplus water, in process of construction at the present time, are mainly the natural basins at the head of the Mississippi proper; namely: Chippewa, St. Croix, Crow Wing and Wisconsin Rivers. To hold the water subject to control, a dam is to be constructed across the lowest rim of each basin—that is that part of the rim which is the drainage outlet of the basin. In each case the discharge gate of the reservoir will have an area not less than the cross section of the stream at low water.

The area of the basin of the Mississippi above the Falls of St. Anthony is, according to the surveys of the U. S. Engineer Corps, 19,900 square miles. The average rainfall observed during a perion of sixteen years is not less than 25 inches per year.* Of this entire amount it has been found that 41 per cent. is discharged at Sauk Rapids, and, by comparing the gaugings at Sauk Rapids and St. Paul, Major Farquhar estimates that the minimum of 33 per cent. of the rainfall is discharged at Pokegama Falls.

Of the entire territory drained by the Mississippi above the Falls of St. Anthony, the reservoirs proposed and under construction aggregate as follows:

Reservoir.	Area of Basin in Square Miles.	Capacity in Cubic Feet of Water.
Winnibigoshish Lake †	1,892	36,629,000,000
Leech Lake †	1,001	19,379,000,000
Mud Lake	161	3,098 000,000
Vermilion River	432	8,383,000,000
Pokegama Falls †	179	3,465,000,000
Total above Pokegama	3,665	70,954,000,000
Pine River†	551	10,668,000,000
Gull Lake	272	5,266,000,000
Mille Lacs	444	8,684,000,000
Grand Total	4,932	95,572,000,000

† Completed.

From the foregoing it is seen that 95,572,000,000 cubic feet of water may be stored away in the reservoirs on the Mississippi alone. As a matter of fact the reservoirs already completed show an actual capacity of nearly 5,000,000,000 more than their estimated capacity.† Not all of this water is available for storage, however, as 46,000,000,000 cubic feet are required for the constant flow between May and December, leaving a minimum of 49,000,000,000 cubic feet (with a possible ten per cent. more) available for storage. Now, the mean flow opposite St. Paul is about 28,000 cubic feet per second, but there is a good navigable stage of water in the Upper Mississippi when the volume is reduced to 12,000 feet per second. During the low stage of water of 1874, the amount of discharge fell to 7,000 feet per second, an unusually low stage. If we consider this the minimum low water, and add the discharge of the Minnesota River (about 800 feet per second), which flows into the Mississippi about five miles below St. Paul, there is needed but 4,400 cubic feet per second to be supplied from the reservoirs. The low stage of water begins about the middle of August, and never before the middle of July. But on the supposition that it continued for four months, the amount to be drawn from the reservoirs would aggregate only 42,000,000,000, against an actual amount of not less than 49,000,000,000 cubic feet in the reservoirs. Even 5,800 cubic feet per second could be spared if we consider the increased actual capacity over that estimated.

The reservoirs named in the preceding paragraphs are those on the Mississippi proper only, the Wisconsin, Chippewa, Crow Wing, and Fox Rivers not being included in the available storage supplies. The available supply, when these rivers are included, can be increased to a possible 40,500 cubic feet per second for ninety days.‡ The reservoirs once constructed at the sources of these streams will not only give a much more uniform volume in the Mississippi, insuring a fair stage on all bars, but it will also add several hundred miles of navigable waters to the great system of river transportation. These streams are mentioned, not because they are more important than such rivers as the Minnesota, Des Moines, and other large rivers below, but because of their being the outlets of a thousand and one lakes in the northern part of Minnesota and Wisconsin; their freshets may be an important factor in the more disastrous floods of the lower Mississippi.

It is true that the estimated 40,500 cubic feet per second now about to be controlled seems ridiculously insignificant when compared with the 960,000 feet per second which passes Pointe a la Hache near the mouth of the river.§ But this is certainly 40,500 feet more at extreme low water and 40,500 less at high water; in other words, it reduces the extremes by 81,000 cubic feet per second. Furthermore, the same plan may be carried out with other tributaries in the course of time so as to control twice or thrice the amount if necessary, selecting in each case those streams in which there are the greatest extremes of volume.

There is one point in which the Ohio River furnishes a most valuable lesson. During the past ten or fifteen years, the floods of this river have been growing more and more disastrous, and the low stage lower with succeeding years. The reason is not hard to find. Every landowner finds it desirable to get rid of the surface water that falls on his land. He leaves no stone unmoved or furrow unturned that will enable him to do this as quickly as possible. He, naturally enough, drains the water into the most available channel; and that is, of course, a river, creek, or smaller brook that is finally tributary to the main stream. Add to this the fact that, perhaps, one-half the sodded land, which has a wonderfully great saturative quality, is converted to cultivated land which possesses this quality in a much feebler degree, and we can readily appreciate how rapidly the water, falling as rain, is drained from the surface to the river. Throughout the entire basin the water, which should otherwise soak into the soil or evaporate, is conducted to the river channel. Moreover, every square mile of forest timber is quickly shorn of its timber by an army of lumber speculators. There can be but one result. The waters, deprived of their former restraining influences, collect rapidly in the main channel; and, as the channels have neither the capacity nor the slope to drain the water away, they quickly fill bank full, overflow, and spread all over the flood plain. Thus the floods have been coming down the river year by year, and each succeeding decade has seen them a little greater, on the average, than the one preceding it. At Cincinnati, the Ohio has reached a flood height of 71, and the Mississippi, at St. Louis, a flood height of 42 feet above low water stage. There can be but one moral—a certain amount of park land must be reserved along all streams which are subject to severe floods, and this land must be kept covered with sod, timber, or thicket. The *reboisement* of the steeper water shed slopes in southern France has done much in recent years to prevent torrential flooding of streams, and it is not unreasonable to suppose that it would be any less effective along the tributaries of the Mississippi. With the possible exception of the basin of the Ohio, but little land belonging to private owners needs to be condemned; there is plenty of public land that may be set aside for the purpose. It goes without saying that a step of this kind is imperative, and that the necessity and the cost as well will increase with coming years.

APPENDIX.

Tributaries of Lower Mississippi.

H. L. ABBOT, Col. U. S. Eng.

RIVER.	Distance from mouth.	Height above sea.	Width between banks.	Range between high and low water.
	Miles.	Feet.	Feet.	Feet.
MISSOURI.				
Source	2,908	6,800 (?)		
Fort Benton	644	4,319	1,500	6
Sioux City	842	1,065	2,250	
St. Jo	484	756	3,000	20
Mouth	0	381	3,000	35 *
UPPER MISSISSIPPI.				
Source	1,330	1,680		
Swan River	998	1,290	120	
St. Paul	658	670	1,200	20
Rock Island	310	505	5,000	16
Mouth	0	381	5,000	35
OHIO.				
Coudersport	1,265	1,649		
Pittsburg	975	699	1,200	45
Cincinnati	515	432		71 †
Mouth	0	275	3,000	51
ARKANSAS.				
Source	1,514	10,000	150	
Bent's Fort	1,289	3,672	5,000	6
Great Bend	992	1,658	5,009	
Fort Smith	522	418	1,500	25
Little Rock	250	252	1,500	35
Mouth	0	162	1,500	45
RED.				
Near Source	1,200	2,450	2,000	8
Preston	820	641	2,000	
Shreveport	330	180	800	25
Mouth	0	54	800	45 ‡

* Largely back water from Mississippi.

† Highest ever known.

‡ Mainly back water from Mississippi.

THE LOWER MISSISSIPPI.

	Distance from mouth.	High water elevation.	§Slope per mile.	Width between banks.	Range between high and low water.
	Miles.	Feet.	Feet.	Feet.	Feet.
Mouth of Missouri	1,286	416			
St. Louis	1,270	408	0·5		37
Cairo	1,097	322	0·497		51 *
Columbus	1,076	310	0·571	4,470	47
Memphis	872	221	0·436		40
Gaines Landing	647	149	0·32		
Natchez	378	66	0·309	4,080	50
Red River Landing	316	40	0·266		44
Baton Rouge	245	34	0·22		31
Donaldsonville	193	26	0·156	3,000	24
Carrollton	121	15	0·147		14
Fort St. Philip	37	5	0·119	2,470	4·5
Head of Passes	17	3	0·115		2·3
Jetties	0	0	0·17		00

* Due to flood of Ohio.

position, offer the greatest resistance; but some point to the right or to the left will be selected. The outflow through this breach soon draws down the level above, and, the velocity diminishing, the water is no longer able to move the sand through the gap, drops it there, and the breach fills up. Another outlet will, after a time, be formed, but, for the reasons before given, it will be farther from the center of the wave than before; and this action will be repeated as often as there is any disturbance of equilibrium. In any case the rule is the same; the breach is formed in the sand dam or bar as near the axial line of the stream as the composition of the bar will allow. In consequence of this action, the water no longer flows parallel to the sides of the channel, for, on emerging from behind the sand wave, it necessarily strikes at the side of the angle, and it will then be deflected back, and hence the breach in the next lower pool will take place on the side opposite the first one. The channel will now follow a series of osculating curves, whose degree of curvature will be mainly regulated by the density of the sand and the amount of water in motion. If now the supply of water be restored to the original volume, the channel will return nearly to its original direction; but if the foregoing operation be many times repeated, the lighter materials will, to a great extent, be sifted out of the central part of the sand-waves, and these will finally attain a sufficient density to oppose the full strength of the current."—*C. R. Suter, Maj. U. S. Eng.*

* From 1871 to 1874, inclusive, it was slightly in excess of 36 inches. At St. Paul it is 29 inches. The average of 25 inches is probably too small.

† Appendix A. A., Annual Report of Chief of Engineers, 1885.

‡ Appendix X., Annual Report of Engineers, 1883.

§ During 1882, of the total volume of the Mississippi, 11·6 per cent. came from the upper river, 19·5 per cent. from the Missouri Valley, 33·5 per cent. from the Ohio Valley, and 35·4 per cent. from the lower river, including Arkansas and Red Rivers.

IN the past twenty years, as shown by the recent census, every class of public debt in this country has decreased. The national debt has gone from $61.88 to $13.81 per capita. The State debts have decreased from $9.15 to $2.43 per capita, county indebtedness from $4.78 to $1.84, and municipal indebtedness from $10.52 to $9.92 per capita. The total per capita indebtedness, according to the census bulletins, has decreased from $75.90 in 1870 and $56.35 in 1880 to $28 in 1890.

LACTIC ACID: A NEW INDUSTRY.

THE problem of the production of lactic acid on the large scale, and at a cost sufficiently low as to offer the all-important incentive to its industrial consumption, appears to have been solved. The Nelson Manufacturing Co., of Newton Upper Falls, Mass., are now manufacturing the acid and putting it on the market in the form of a 33 per cent. solution, selling at 5 to 7 cents per pound; the lower-priced acid having a brownish color, the higher being perfectly colorless.

The introduction of the acid to commerce is a fact of some importance, and we, therefore, place before our readers some particulars as to its production and applications, which deserve careful consideration.

The souring of milk is one of those "spontaneous" processes with which we are all familiar, as we are, too, with some of the qualities of the product.

There are some of us, however, who may know for the first time that there was a period when the bleachers of the north of Ireland employed lactic acid in this form for souring their linen goods after the crude ash boil, then also in vogue. But, since the time when Scheele first extracted the lactic acid, in 1780, its uses have been confined within a very narrow field. It was nearly a century later that the special fermentation of which it is the product was elucidated by MM. Boutron and Frémy (Ann. Chim. [3] 2, 257). But, even in the light of their researches, the process has been found to be exceedingly difficult to control, and it has been reserved to an American chemist, Mr. C. Waite, of Boston, to bring about the conditions under which pure growths of the lactic organism, in a solution of glucose, can be "operated" on any desired scale.

We may remind our readers that the splitting up of glucose into lactic acid is expressible by the simplest possible empirical equation:

$$C_6H_{12}O_6=2C_3H_6O_3$$

The question naturally presents itself, why so simple a transformation should completely baffle the chemist. The answer to this is contained in the analysis of the above empirical into constitutional formula as follows:

$$\underbrace{CH_2.CH.OH,\ CH.OH,\ CH.OH,\ CH.OH,\ CH.OH}_{O}$$

Dextrose.

$$\underbrace{CH_3,\ CH.OH,\ CO.OH}$$

Lactic acid.

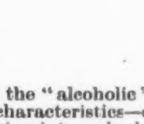
The redistribution of oxygen and hydrogen within the molecule, resulting in its bisection according to the equation, is seen to imply a subtilty of control as yet altogether outside our reach. In the meantime, however, we can get the organism to do the work for us, taking advantage of its superior intelligence, fortunately united to an uncomplaining devotion to its life's work for at least 24 hours per day. The fermentation process, as carried out by Mr. Waite, is so perfectly under control that 98 per cent. of the total acidity of the fermented liquors is due to the main product—lactic acid. Of this process we do not propose to speak further. It is sufficient for the purpose of this article to assume a supply of the 33 per cent. acid, produced at a cost of 5 cents per pound. We desire to call attention to the applications of the acid, some of which promise to be of the greatest importance to the textile industries.

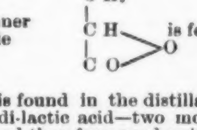
Some of these industrial uses of the acid are suggested by its special properties. It is non-volatile, does not attack cellulose, and is, of course, without action on the fibers of animal origin. It differs in constitution from acetic acid by the interpolation of a CH.OH group, thus:

$$\begin{array}{c} CH_3 \\ | \\ COOH \end{array} \qquad\qquad \begin{array}{c} CH_3 \\ | \\ CHOH \\ | \\ COOH \end{array}$$

Acetic acid. Lactic acid.

The pressure of the "alcoholic" OH group—which has weakly acid characteristics—confers the property of very easily passing into anhydride modifications by simply heating.

Thus the inner anhydride  is formed by distilling the acid, and is found in the distillate and the semi-anhydride or di-lactic acid—two molecules losing together $1H_2O$ and therefore condensing to the form of



on heating to 130-190° C.

These anhydrides combine readily with water to reform the acid. The acid forms salts with one and with two equivalents of monohydric bases; in the ordinary lactates, however, the alcoholic OH group remains free.

An acid of such properties recommends itself for a variety of applications in the dyeing, printing, and finishing of cotton and linen goods. Some of these have been practically tested by Prof. L. M. Norton, of Boston, and the results reported in the *Textile Record* of August and September, 1890. Thus, as a substitute for tartaric acid in the white discharge upon turkey red; for citric acid in the yellow and brown discharges (with lead salts) on turkey red; for acetic acid in the preparation of alumina mordant. In addition to these uses favorably reported upon by Prof. Norton, we would suggest its use as the acid ingredient in mixtures for various steam styles, in the dyebath where a non-volatile acid is required, and as the acid ingredient in certain finishing mixtures.

Perhaps the most favorable results are those obtained by Norton and Tuttle, in substituting lactic for tartaric and oxalic acids in wool dyeing. The lactic acid used in these experiments was a solution of 48·5 per cent. strength. In illustration of these we cannot do better than give a brief abstract of their investiga-

tions (loc. cit.) Samples of wool mordanted with the following proportions:

(a) Bichromate of potash........ 2·5 per cent.
Tartar.......................... 2·5 "

(b) Bichromate of potash........ 2·5 per cent.
Acid lactate of potash....... 2·5 "

(The acid lactate was prepared by half neutralizing with potassium carbonate.) In dyeing out with alizarine (b) gave a distinctly heavier shade, showing that more chrome was fixed with the lactate.

A similar result was obtained with bichromate and lactic acid (1 per cent.) as against oxalic acid (1 per cent.) Samples mordanted with chrome and alum as under:

(a) Bichromate.................... 1 per cent.
Alum............................10 "
Oxalic acid..................... 1 "

(b) Bichromate.................... 1 per cent.
Alum............................10 "
Lactic acid..................... 1 "

In this case, also, (b) gave the heavier shade on dyeing out with alizarine.

The most striking results appear to have been obtained in substituting the acid lactate for tartar, in mordanting with tin. Samples were mordanted as follows:

(a) Tin crystals.................10·0 per cent.
Tartar..........................10·0 "

(b) Tin crystals..................10·0 per cent.
Acid lactate....................10·0 "

With regard to the colors obtained on dyeing out with alizarine, the authors say (a) gave the well known reddish orange, while the lactate shade was a very brilliant yellowish red of great beauty, such as it has hitherto been very difficult to produce upon wool with alizarine.

Generally it results from these experiments that with lactic acid there is a greater fixation of base, and this was proved by the following experiment: Three baths were prepared containing equal weights of alumina in one series (a), and copperas in another (b), and of tartar, acid oxalate of potash and acid lactate of potash respectively.

After mordanting equal weights of wool, the baths were analyzed, with the following results:

		Tartar.	Acid oxalate.	Acid lactate.
(a)	Alumina fixed	63·5%	71·8	80·0
	Alumina remaining in solution	36·5	28·2	20·0
(b)	Iron fixed	40·4%	47·5	60·2
	Iron remaining in solution	59·6	52·5	39·8

The samples were dyed out in alizarine, and the results were in accordance with the above analytical results, but, it is to be observed, more in favor of the lactate shades than the proportion of the numbers would indicate, showing that the lactate exerts a positive effect, in addition, in the coloring matter.

With the dyewoods, on the other hand, which were similarly investigated, the results obtained with the lactate mordant compare unfavorably; this also argues for a positive influence on the coloring matter. However, the net result of the investigation is to show that lactic acid can be advantageously used in a large number of dyeing and printing processes, and many other applications will suggest themselves, more especially to those engaged in these arts.

The employment of lactic acid for dietetic and pharmaceutical purposes cannot fail to be considerably stimulated by the new supplies now promised. Its use as an ingredient in acid beverages is already considerable in the States. It is in many ways a more agreeable acid than vinegar, and we shall not be surprised to see a considerable displacement of the latter by the new candidate for popular favor.

However, it is not the purpose of this brief notice to do more than hint at the possible development of this new industry. It is an interesting sign of the times we live in to see this somewhat refractory micro-organism—the lactic ferment—impressed into the ranks of industrial production. Such achievements bring us a step nearer the goal of finding out "how it is done." The splitting up of $C_6H_{12}O_6$ into $2C_3H_6O_3$ looks so absurdly simple: in modern science, however, the empirical formula counts for very little, but the micro-organism commands our deepest respect as possessing the key to molecular mysteries which are still a great way off.—*Chem. Tr. Jour.*

THE CHEMICAL COMPOSITION OF ASBESTOS.*

By J. T. DONALD, M.A.

WHEN Canadian asbestos was first placed upon the market it had to compete with the Italian mineral, and attempts were made to decry the Canadian article and to prejudice users by the statement that chemical analysis showed the latter to be inferior to the Italian. From different sources samples of the Italian were procured, and an analysis was made of the best, the results of which are shown in the first column of the following table. Column 2 shows the composition of a sample from Broughton, which was taken for analysis because of its marked freedom from foreign matter, the Thetford samples first selected for that purpose having been damaged by fire and smoke.

	Italian per cent.	Broughton per cent.	Templeton per cent.
Silica	40·30	40·57	40·52
Magnesia	43·37	41·50	42·05
Ferrous oxide	0·87	2·81	1·97
Alumina	2·27	0·90	2·10
Water	13·72	13·55	13·46
	100·53	99·33	100·10

These results show that the chemical composition of the Canadian fiber is in nowise inferior to its European rival.

Chemical analysis throws light upon an important point in connection with asbestos, *i. e.*, the cause of the harshness of the fiber of some varieties. From the analysis given above it may be seen that asbestos is principally a hydrous silicate of magnesia, *i. e.*, silicate of magnesia combined with water. When harsh fiber is analyzed it is found to contain less water than the soft fiber. In fiber of very fine quality from Black Lake analysis showed 14·38 per cent. of water, while harsh-fibered sample gave only 11·70 per cent. It is well known that if soft fiber be heated to a temperature that will drive off a portion of the combined water, there results a substance so brittle that it may be crumbled between thumb and finger. There is evidently some connection between the consistency of the fiber and the amount of water in its composition. It is probable that the harsh fiber was, as originally deposited, soft and flexible, and has been rendered harsh by having a portion of its water driven off by heat, either produced by movement of the associated rocks or resulting from the injection of molten matter through volcanic action.

Up to the present time Canadian asbestos may be said to have been obtained exclusively from the Cambrian rocks of eastern Canada. Of late, however, indications have not been wanting to show that it is possible that the great belt of Laurentian rocks to the north of the St. Lawrence may yet prove to be a rich source of this mineral. It has long been known that seams of short fiber are to be found in those rocks, but it is only within the last year that any attempts have been made to test these veins, and it is gratifying to be able to state that the results of these attempts are promising. Much of the Laurentian serpentine is different from that of Thetford and Black Lake. It is much lighter in color, and is remarkably free from disseminated chromic and magnetic iron. The contained asbestos is, like the serpentine, of a lighter color than that from the Cambrian, and in consequence of the absence of iron there is little or no tendency to discoloration from percolating water. The sample of asbestos from Templeton, of which an analysis is given in the above table, was from the Laurentian rocks, and, so far as its composition is concerned, is practically of equal value with the Cambrian asbestos of Broughton.

* From a paper read before the General Mining Association of the Province of Quebec, April 29, 1891.

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